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THE PARIS AERO SALON 1913. GENERAL VIEW.—[See page 24.]

How to Harvest Ice Rapidly

An Industry in Which Speed is of Prime Importance

By Harold B. Wood

It is astounding to note how few men appreciate the advantages of a rapid harvest. It doesn't seem to disturb the average iceman at all when he averages but 1,500 to 2,000 tons instead of 4,000 to 5,000 tons per day. Perhaps he thinks it costs more to harvest more because it requires more men. At any rate, there doesn't seem to be the general desire to harvest rapidly.

Hundreds of others, who do in a measure appreciate the advantages of a quick harvest, do not know how to bring it about. Others believe they are doing as well as possible and don't believe the stories that they hear of fast work.

Some seem to pay particular attention to one section of the work, say the field, the canal, or the house. It is surprising to note how few look after the vital points and keep everything moving along synchronously.

Many have lots of excuses. They say they have no good foremen, no good bosses and the class of labor is bad. There is a great difference in labor, but improvement can be made with any conditions. Where there is a will there is a way.

First of all, what does the word rapidly mean? What is rapid harvesting? Some call 2,000 tons per day good work; some talk about 3,000 tons, but with a large house these capacities are very low. Of course, a large house is necessary. Nobody ever filled a 5,000-ton ice house in one day and nobody ever will.

A housing rate of 4,000 tons per day is not sufficient; 5,000 should be put up on an average, so let us prepare for 6,000 so as to insure an average of 5,000 tons. A figure of 5,000 tons is not at all unreasonable or unusual.

People often say that there is a little that can be done toward reducing the cost of the harvest, but I am absolutely positive that with the exception of a very few cases, there are thousands and hundreds of thousands of dollars thrown away every year in the natural ice industry by dallying over a harvest for 12 to 18 days instead of cleaning it up in 6.

It has been my lot to study harvesting operations in a great many different States, and the one thing that has impressed itself upon me more than anything else is the absolute disregard of details which must be looked after carefully to put up a reasonable amount of ice per day. Many have hard luck tales. Very little of it is hard luck. Some men learn nothing by experience. They suffer by the same delays year after year, all of which could be avoided.

Large operators are at a disadvantage because they must rely upon superintendents, and yet if superintendents are not given a house properly located with a good equipment, they cannot accomplish the desired results.

The whole thing is a matter of system, and of team work. A baseball team cannot win a game by simply having a fine pitcher any more than the ice man can put up ice by having a fine house. The fielders must support him in the ball game, and the field, canal and elevator must support the house in the ice game.

These are every day facts. What I may say, I have seen, and if every injunction herewith set forth is carried out to the letter, there is no reason at all why anybody cannot do it. If any owner lacks the practical knowledge and the executive ability, hire it. There are brains to be had for the hire.

Now 5,000 or 6,000 tons per day as a harvesting rate is a big jump from 2,500, and you can't accomplish it by simply saying "Hurry up boys, wake up there." It probably will mean a considerable investment of money and time, but it pays fine dividends.

There is every advantage in a quick harvest, with no disadvantages except that it costs more energy, more brains, more executive ability and greater effort to secure the necessary number of men of the right kind.

The chances of securing a full crop by quick work are proportionately better, and on a short season I will leave it to you as to what a few extra thousand tons of ice in the house mean. A quick harvest is almost sure to save the ice from some soft weather, resulting in less poor ice in the house. The faster the ice is put in on a good day, the better the quality. A rapid harvest is very likely to dodge a snow-storm, and if so, a lot of money is saved.

Ice harvested quickly costs less, and a good deal less. Irrespective of daily capacity, the preliminary operations of preparing the field are the same; the engineer, the friction tender, planer man (if any), door men, feeder, foreman, timekeeper and many others are the same in all cases, and with a quick harvest they are on the payroll for a shorter length of time.

It doesn't take anywhere near twice as many field men, canal men, operators in the slip, bar men and the like to harvest 5,000 tons, as it does to make a poor run of 2,500 tons. Other classes of men need to be increased but slightly for the doubled capacity, and probably the only set of men that are very nearly proportional to the amounted harvested per day, are the house men. The proposition is a good deal like that of railroads. The cost of transportation is very great with a small tonnage because the fixed charges are so tremendous and such a large part of the whole cost. Additional tonnage can be handled at a very small additional cost, thus reducing the cost per ton of freight. The cost per ton harvested is surely less with a quick harvest. Why is it then that more success is not evidenced along this line?

The worst of it all is that most ice men to bring about any marked improvement would have to start at the beginning and re-arrange the house and equipment.

It would pay to go to more trouble in the first place, to properly grade and lay out the house, placing it far enough away from the water to provide an easy incline, so easy as to avoid the necessity of using knuckle wheels, or any other unnecessary machinery. Arrange it so that the doors do not face the water; arrange it so that the house is not too deep, but long with narrow rooms. If additional capacity is required, go up rather than spread out. Don't stop at 34 or 36 feet, but run it up to 40 feet or 50 feet. When building a house, one's ideas as to the scale of the operations should be considered. If you want to harvest 5,000 tons daily, and are to build a 30,000-ton house, you will fail if you build with less than 12 to 15 rooms.

For old properties there is not enough money spent in rearranging rooms and machinery. It isn't unusual at all to note where poor conditions cause a 5 cent additional cost per ton for the harvest. For 30,000 tons this means $1,500 a year, which would surely go a long way toward paying interest and depreciation and a handsome profit besides on the expenditure required for the re-arrangement. The cases where a fairly good house has been torn down and rebuilt for the sake of proper arrangement are very rare, if there ever was a case, because the man who allows such conditions to exist does not and cannot appreciate the advantages of the change.

Possibly the most essential point is a large number of rooms. You can't take care of 5,000 tons daily in a few rooms. The larger the number of rooms the easier it is to keep things going along smoothly and to make a good run. In fact, the amount of ice that can be harvested is almost proportional to the number of rooms.

Small crews separated in different rooms are able to take care of ice rapidly in a house of 12 rooms or more and 2 or 3 rooms can be changing skids or filling in and the rest will take the full supply of the elevator.

Wide doors help. The doors must be wide enough to admit a chute built so that the ice can run either way, that is, wider in the clear than the diagonal of the cake. The door men should be able to switch the ice any manner and not have to direct it the narrow way, as jamming at times is sure to occur. For ice 22 inches by 32 inches the inside measurement of the chute should not be less than 40 inches.

Do not raise the gallery much at a time—steep door chutes embarrass the room men.

Good planed boards for the room floors, well cleaned, are necessary for a good start.

If there isn't the correct arrangement at the basin, change it to a right angle L canal or an obtuse angle canal. The full width of the float should enter the basin and its direction should be at right angles to the single cake canal. The obtuse angle canal is being tried and is preferred by some. Well-built piers should be provided if possible.

When working rapidly you will be bothered in the small canal by cakes ducking and buckling under. An excellent contrivance to prevent this is to place in position a wooden chute with smooth sides and an adjustable bottom with slats, so designed that the bottom can be adjusted to about 6 inches below the bottom of the ice irrespective of its thickness. This prevents ducking and saves delay for rapid work. Don't fail to have the little canal a 100 feet long in order to give opportunity to catch up if there is a momentary delay in barring off the strips.

The machinery equipment for fast work should be of proper design, but the difficulty does not lie here as a rule. Very few elevators are loaded continually throughout the day to their full capacity. If they were, and all of the ice housed, we would have a lot of new records made. It is the delays and the inability to take care of the ice in the house that limit the day's run.

An absolute necessity is a good planer with plenty of knives, not requiring the knives to do too much work, but setting them for a small cut each, and planing the ice to one thickness. Real fast packing cannot be accomplished in the house without smooth, level floors.

Be prepared for a large amount of chips. Do not take any chance on getting blocked; dispose of the chips by flushing them with a pump and trough, or install a chain chip conveyor to take them away at little cost. Icing up under the planer causes poor ice. Poor ice means a slow harvest. You can't stop to knock the ice off the run, and the irregular motion of the ice under the planer breaks it or makes it uneven. Use pipes or place pipes at the side of the iron slats and run steam into the pipes, or if electricity only is available, rig it so that resistance wires can be run through the pipes.

Have plenty of power; a little surplus is a good thing. Some year, with heavy ice you will want to run very fast the last day and a little extra power is appreciated.

Without any question the average ice man fails to harvest a large amount of ice on account of the fact that he only hoists ice seven hours, or at the best eight hours out of nine. Nothing is more disgusting than the absolute indifference displayed during the harvest at delays. The elevator stops, the men in the house rest on their hooks and not a pound of ice is placed away with 150 men idle, all because of some trivial little point, which is not corrected, but could be corrected just as well as not. A rider must be cut out, the chain runs off the water wheel, the chain comes apart, the chain breaks, the chain runs off the sprocket, a hold bar breaks, or the men in the house cry for mercy as they are getting too much ice. Three out of six rooms will be filling in or back hauling and the elevator must be stopped until they catch up, the planer may give trouble, the chain crowds up under the planer, and with gravity runs there is always trouble with the ice getting caught and blockading. The steam pressure gets a little bit low and the elevator must be stopped to catch up or the engine objects to the heavy work.

Even with fairly good conditions many are doomed to fail. A short time ago I approached the River Superintendent of a large ice firm with this question, "Why is it that some of your superintendents with substantially the same paraphernalia put up twice as much ice as another?" He hit the nail on the head. "Well," he said, "some men don't see things until they get to them." We know just what he means. They don't know that the ice isn't plowed deep until too late; they don't know that the calking has not been done until the ice is actually in the basin; they don't know that the elevator is going to be out of ice until the event actually takes place; they don't know that the rooms are going to be blocked until they are all filling in at the same time.

Some ice men, however, are able to run nearly continuously throughout the day, not stopping more than 10 or 15 minutes out of 9 hours. The delays can be reduced in almost every plant, limiting them to unavoidable accidents beyond the operator's control.

One reason for stopping is a rider or an ugly chunk of ice which will cause jamming under the planer, or at some other point. Prepare to be able to run without stopping for a rider. With the stationary planer, and with the hold bar up on top of a heavy lip or flange of an ice cake, the operator stops and cuts down the flange to let the hold bar down, as otherwise the guards under the planer would be ripped up. These stops are not necessary. Put in a stationary planer and cut a rider right in two rather than stop. The loss of the cake of ice amounts to a cent or less and an elevator can't be stopped and a rider cut out for fifty times this amount. Never let a hold bar get up on a flange. Continue the hold down device clear from the planer down under the water. Put the planer close to the water, run the guards clear down and never let the chain get up at all. This is a simple matter and absolutely prevents any of these unnecessary delays.

You can't bring about these changes by thinking about it; you may have to spend some money. For example, some elevator conveyors were built before the common use of the stationary elevator planer, and are now too narrow to make such a change as this. If so, widen the conveyor. Possibly this point illustrates the principal trouble. The ice man seems to take it for granted that these delays are necessary, that they can't be helped and year after year goes by and no change is made. If they get through the day without many delays, they had good luck; if they happened to get a legitimate number of delays, they had bad luck. There

isn't much luck in this ice game at the harvesting end—play it right and you will win.

If a chain runs off, there is something that is causing it, and the trouble can and should be corrected at once. It is not an uncommon sight to see a harvester operating with a chain with numerous bent links in it. Every time the bent link approaches the sprocket wheel, it *may* cause the chain to run off. Some bent links don't, and some bent links do, and do every time. Every time the chain runs off it bends another link. To let these bent links remain in the chain, or to straighten them imperfectly with a hammer invites further trouble. The next noon or night substitute a new section of chain for the imperfect one.

If in spite of your efforts the chain does run off oftener than once a season, open up the mortises in the chain, make them wider, obtain the bigger lee-way and prevent the trouble by causing the teeth to enter the open links or mortises more readily.

Many broken chains are caused by missing cotter pins. If the chain does actually break, don't let another season go by without putting in a heavier chain. If the machinery isn't strong enough and any part appears weak, take no chances with another harvest; you may have a very severe year, put in new machinery and sell your old machinery to some poor fellow that doesn't know as much as you do.

Before the harvest, go over every detail personally; make sure the engine is in order; the electric bells O. K.; the friction clutch is in perfect working condition; every hold bar satisfactory; every chain bolt with its cotter and washer; every foot of chain perfect; every shaft square; every bolt tight and every rivet with a good head on it. Square up the chain shaft with the run accurately; square the friction shaft to it; line up the pulley or sheave with the engine; oil up everything thoroughly; make sure of every detail and then run the elevator over for several hours to see if everything is correct in every particular. The last of this work should be finished a few days before the harvest.

All this, the preparation—now for the harvest.

If there is snow, scrape far enough ahead of your field so that the markers will not run into drifts.

Keep on hand a surplus of tools everywhere. On the field, for example, be provided against contingencies. One marker hits a stone, then the other one is put out of commission. Have a reserve marker. Don't rely upon one 22-inch guide and one 32-inch, but have extras. Suppose one gets caught in a partially frozen groove and is badly bent. Put a reserve in its place at once. Do not jeopardize the whole system by failing at the field. The ice must be prepared without any hitches.

If the ice usually runs 12 inches thick, reckon on its being 16 inches next year and have on hand one 12-inch plow so as to be able to plow down nearly to the water. "Where is your 12-inch plow?" I have said on the field. "You need to groove 12 inches deep for 16-inch ice, and you are using an 8-inch for the last cut." "Well, my ice seldom gets over 12 inches or 13 inches, and an 8-inch plow is usually enough." For the want of one plow he reduced his daily run, although he knows not the reason, from 3,000 to 2,500 tons on account of the heavy flanges and lips which give trouble all along the line.

Plow down; plow down smack to the beam. Go over it again and get down all the camel backs.

Set a standard for a given thickness of ice and hold the field foreman absolutely to a certain depth for every groove. Take a trip to the field at frequent intervals and put your rule down into the groove yourself. Don't wait for complaints at the basin. Check the complaints by checking up the field foreman yourself.

If you never do anything else, calk, calk, *calk* those seams. Plug them tight.

On your way from the house to the field, jump on a float and look it over. See if the water has entered, and if so, call the field foreman's attention to the fact. The men are not watching for water from cracks or are not getting to the bottom of the grooves with the calks. Make the men clean out grooves before they start to jamp. Be energetic and do some walking around, providing yourself with a sufficient number of good foremen so as to have no particular duty fall upon you, but be able to supervise all of the operations.

Bar off large floats at regular intervals—don't slip up. By regulating it and preventing delays, this work can be made almost part of the clock. Never being too late at the basin and never allowing the floats to accumulate so as to freeze solid if particularly wet.

These floats must be kept dry. Prevent side wash by the method of opening up the field if possible—don't allow open water on the side with a heavy wind to wash over the side of the float. If you have open water on one side of the long canal and prefer to work that way, anchor a long boom or break-water made up of telegraph poles on the open side, thus breaking the waves. Prevent wash on the front, with a head wind, by extending a temporary board ahead of each float on its way to the basin in much the same way as you protect the face of your field with old headers at night.

If a float does get flooded on a sharp day, make dead sure that somebody whose duty it is, discovers it in time and side-tracks the float without allowing it to get to the basin.

Ice poorly grooved or half frozen, one poor float flooded and frozen in the basin, causes an immense amount of delay and easily spoils your chances for a record run. Any continuation of poor ice at the basin will drop the daily harvest to a very low figure.

In watching some icemen, I have yet to witness a float thrown away for any reason or other. Watching others on almost any very cold day, complete floats will be seen to one side of the basin discarded. The latter is the proper procedure when a defective float is on its way to the basin. Irregular ice causes trouble on the elevator, causes riders and makes no end of delay.

It is the height of folly to allow a partially frozen float to get into the basin. It is nearly as bad as drift ice, and you all surely fight bravely against that.

But careful as you may be, ice will come a little bad at times Then it is that it is important for the bar men on the floats, subdividing into the strips, to strike simultaneously. If the groove is frozen a little at one end, careless work will start a break through several strips and ruin a number of cakes and make many ugly pieces. Intelligent work, striking together with no prying would make more perfect cakes and fewer pieces.

If all this is looked after, each groove is deep and distinct for the bar men in the single cake canal, almost every cake will be square and perfect without broken corners or bad lips and the harvesting proceeds merrily—yet, we all have seen ice in the little canal when you could not find the plow grooves, and the owner explained his poor run by saying that it was too cold, the grooves got all frozen up.

No matter what method you employ, no matter how you keep your canal open, or how your night men let it freeze up, hire watchmen to watch the night watchmen if necessary and have ice at the elevator at 7 o'clock every morning without fail, because if you don't you have checkmated all possible chance for a creditable showing for the day.

Feed the chain with good ice and feed it regularly, two cakes on every bar, without a miss. You have arranged matters so that it can be taken care of in the house, so don't stop for anything.

The ice then passes without a stop under the planer set at one level and slides along the gallery.

The ice should not be allowed to hang over the ice guard on account of being shelled under, to strike the gallery hoist posts or wire ropes supporting the galleries; neither should the ice have a solid square corner to buck against when being switched into the room. All ice guards at the doors should be built in a proper manner so as to make any jamming impossible. A cake of ice caught squarely between the chain and the square edge of an ice guard can break a pocket or chain. By putting the walk on the inside between the run and the house, an accident of this character can never take place if corner irons or ice guard fenders are used.

If you haven't 12 or 14 or more rooms, exercise care in preventing the rooms keeping together. If several are filling in, back-hauling or changing skids at the same time, you will have either to stop the elevator or slow up on the feeding. This should never be done.

Use light skids that can be handled quickly. Be systematic—lay the runs directly back on the tier just placed in perfect order, opposite the marks on the walls to indicate the proper points, so when the layer of ice is filled out all that is necessary to do is to pull the runs a few inches ahead and hook them up.

By brains and ability, and this seems to me to be the principal requisite, some harvesters have been able for years to house large amounts of ice per day.

A house with 63,000 tons capacity has been filled in eleven days over one chain. 21,000 tons of ice have been stored in *one house* over *one chain* in *three* consecutive days.

Yes, this ice was cut 44 inches by 44 inches square, which expedites the harvest to be sure, but the smaller ice can be put up just as fast.

Poorer records are made on the Hudson River, not so much because the ice is smaller, but because there are additional difficulties to contend with; but at the Flatbush house on the Hudson 4,000 is reached at times and 4,000 to 4,500 is housed at intervals at Rattlesnake.

The real palm for actual accomplishment must be given to the Worcester harvester who cuts ice 20 inches by 28 inches; planes it to 12 inches and yet harvests 5,000 tons per day regularly day after day—33,000 tons in 60 running hours, and for a *single day* of 10 hours 6,500 tons.

The organization at this plant is splendid. With this organization, with the house situated more correctly, with a different elevator equipment, this company could, I am confident, run at a rate of 7,000 tons per day regularly. This rate is perfectly possible and should be the aim of all.

I am longing for the day when some iceman will grow ambitious and come to me and say, "Well, Wood, I am doing 5,000 now, but I want to do 7,000, and it is up to you. My one elevator will not take, with the unavoidable delays and missed hold bars, more than 6,000, and I want 7,000 on one chain."

The size of his ice is 22 inches by 32 inches. The problem is simple, thoroughly tried out and practicable.

Consider the long continuous elevator conveyor where the double chain passes the doors and the power and engine are placed at the extreme rear of the house. Instead of making the space in the clear between the ice guards 42 inches, sufficient to take two cakes on a hold bar the 32 inches way across the incline with hold, bars 5 feet apart, cut the blocks in the field and subdivide them in the canal 44 inches wide and 32 inches long, making two united blocks on every hold bar the 22 inches way across and 32 inches up the incline. The ice as fed on to the elevator is 44 inches wide and 32 inches long, requiring a run 54 inches wide instead of 42 inches. The hold bars are placed 4 feet apart instead of 5 feet, and each hold bar carries one large cake.

Appreciate, I pray you, one point. For each two cakes 22 inches by 32 inches you have in the canal and on the lower part of the elevator only four corners and four sides to be bothered with instead of eight corners and sides, and you well know that it is sides and corners which hinder rapid harvesting.

With the same chain speed a far greater capacity is secured and the bother of handling little blocks at high velocity in the canal is corrected. These blocks are subdivided *on the elevator* into cakes 22 inches by 32 inches, making two cakes to each hold bar, but a much greater capacity is secured as you can easily run at 50 hold bars per minute or 100 cakes per minute. There is hardly a limit to what can be done.

It is better than a wonderful play at the theater to be the silent witness of a good harvest; the animated field, stately elevator and majestic house the stage, and the snow-capped hills the scenery. To see checkered rafts of beautifully plowed and calked ice on their way to the elevator, with the regularity of the companies of a regiment, reaching the basin as dry as a bone, subdivided into regular square-cornered blocks and crowded on to the elevator with perfect rhythmic beat. To see them cut down and shorn of sap and soiled top ice, corrugated to a blue crystal, moving majestically along the run until its beauty strikes the fancy of some cruel door man who stabs it with his pike and diverts it to the house run. Then the never failing force of gravity, which keeps us to earth and prevents us from flying into space like drops of water from a wheel, pulls it onward and onward until another savage switcher with feet and back braced for the encounter, takes his turn and finally with gentle caresses its good friends the packer and spacer guide it tenderly to its resting place, being careful to separate it well from its fellows for whom it has too great an affinity in the good old summer time.

The New Quartz-tube Mercury Arc Lamp

OWING to the difference in the coefficients of expansion of quartz and platinum it is not possible to seal in platinum electrodes. Tungsten electrodes can be sealed in with a special borosilicate glass of high melting point, and with a coefficient of expansion equal to 3.4×10^{-6}. This answers perfectly and renders it possible to use a higher temperature in the lamp without leakage. A current density three times that customary with platinum electrodes can be used, and the dimensions of the lamp are considerably reduced. The 110-volt lamp is only about five inches long. The use of tungsten also enables a solid anode to be used. This renders superfluous the complexities ordinarily considered necessary to balance the difference in evaporation of mercury at the electrodes. The lamps can be conveniently mounted in a vertical position so as to give a high horizontal illumination. The specific consumption of the 220-volt lamp is said to be 0.55 watt per mean spherical candle-power, the 110-volt lamp is rather less efficient. The lamp is being developed for use on alternating circuits and for series lighting.—*Journal of the Franklin Institute.*

Salt Increases the Fertility of the Soil

SEA-SALT seems to play a rather important *rôle* in the development of plants. M. Armand Gautier explains its fertilizing properties by the fact that chloride of sodium favors the solubilization of potassic felspars. M. Andreé, in whose name the paper on the subject is presented to the Academy, adds that carbonate of calcium and sulphate of ammonium do the same. They favor the dissolution in water of the felspars, and of potassic salts, which constitute the mineral aliment of plants. —*Chemical News.*

THE forests of Florida contain 175 different kinds of wood.

The Strength of Long-Seasoned Douglas Fir and Redwood*

By Arthur C. Alvarez

INTRODUCTION.

SINCE there are very few actual test data on the strength of structural timber that has been air seasoned for a long time, the following results are published for the purpose of showing the effect on its strength of a long period of use in a building.

MATERIAL USED.

The specimens for these tests were selected from the wall studding, floor joists, and underpinning of a one-story frame building erected on the University of California campus in 1874, and demolished in 1911, making the age of test specimens 37 years. The wall studding and floor joists were of 2 x 4 inch and 2 x 8 inch Douglas fir respectively, the underpinning of 3 x 4 inch and 4 x 4 inch redwood. All the Douglas fir could be classed as of No. 1 grade. All knots were sound; few knots were larger than one inch. The redwood specimens were of similar grade. The smaller pieces of Douglas fir cut for compression and shear tests were clear timber. There was not the slightest indication of decay on any of the material. Age had merely darkened its surface slightly.

The conditions to which all the material was exposed in service are described as follows: The floor level of the build ng was about 3 feet above ground surface. Air could circulate under the floor through occasional latticed ventilators placed on all sides under the water table. The interior finish was of lime plaster on wooden lath; the exterior was painted redwood channel rustic The building was freely exposed on all sides to light and air. For a period of about 4 months in the year the ground surface in the vicinity of the building in question was usually very damp, a condition favorable for the decay of the fir floor joists, which were only 2 feet above ground. Clearly, here, ventilation prevented decay. The weight of the timber as tested clearly shows the extent to which air seasoning took place under these conditions.

TESTS MADE

Bending, longitudinal compression, and longitudinal shear tests were made on Douglas fir. The material available allowed of only longitudinal compression tests of redwood.

DOUGLAS FIR TESTS.

1. *Bending.*

The specimens consisted of 2 x 8 inch sawed floor joists. Twenty-five tests were made, using spans ranging from 6 to 10 feet. The tests were made on an Olsen 200,000-pound universal testing machine. Loads were applied in increments of 400 pounds each, at the third points of the span. The speed of the machine was .04 inch per minute. Center deflections were read to .01 inch directly by the mirror-scale-thread method. Fig. 3 shows the arrangement of the testing machine for these tests.

The elastic limit and coefficient of elasticity were determined in the usual manner from deflection curves. These curves showed that the elastic limit in each case was very well defined even though the table shows it to vary greatly in amount for various beams. Up to the elastic limit the curves adhered uniformly very closely to a straight line. The fiber stress at the elastic limit was determined by $M = 1/6\ fbd^2$, the usual formula for resisting moment of a beam rectangular in cross section, where f is the intensity of fiber stress at the top or bottom of the section, b is the width of the beam and d its depth. This formula was also used to compute the fiber stress at the maximum load. While theoretically inapp icable beyond the elastic limit, such use of the formula gives valuable comparative results. The modulus of elasticity for a beam loaded at the third points is given by $\frac{23}{1296}\frac{wl^3}{dI}$, where w is the total load applied, I, the moment of inertia of the cross section about its neutral axis, d, the center deflection, and l, the span. Theoretically this formula is slightly in error in that it does not consider shearing deformations. Since the intensity of horizontal shearing stress at any point in a beam equals the intensity of vertical shearing stress, the maximum longitudinal shear in a wooden beam equals the intensity of vertical shear at the neutral axis which is given by the formula $v = \frac{3}{2}\frac{V}{bd}$ where V is the total external shearing force. Table 1 gives the results of flexure tests of Douglas fir.

Modes of Failure.

Ten beams failed in longitudinal shear near the supports; 8 failed in tension at lower fibers due to presence of knots; 5 failed in tension due to cross grain; 2 failed in compression at upper fibers.

2 *Longitudinal Compression.*

The specimens were sawed from tested floor joists and from 2 x 4 nch wall studding. One hundred and twenty-five tests were made on pieces 2 x 2 x 8 inches in size. The tests were made on a Rich e 100,000 pound universal testing machine. Compressive strains were read with an Olsen micrometer compressometer reading to 0.0001 inch for load increments of 1,000 pounds. Fig. 1 herewith shows the arrangement of the apparatus for this test.

The elastic limit and coefficient of elasticity were determined rom stress-strain diagrams. The elastic limit in each case was fairly well defined by the curve. The plotted points up to the elastic limit did not conform to a straight line as well as did those of the deflection curves fo joist tests. However, the deviation from such a straight line in any case was not sufficient to cause any doubt as to its proper position. The results of compression tests are summarized in Table 2.

TABLE 1.

BENDING STRENGTH. DOUGLAS FIR.

Quantity	Average	Maximum	Minimum
Dimensions:			
Section, in.		2.0 x 8.0	1.6 x 7.5
Span, ft.		10	6
Number of rings per linear in.	14	25	4
Weight, as tested, lbs. per cu. ft.	34.4	43.9	27.5
Sapwood, per cent.	0.5	10	0
Elastic limit:			
Total load, lbs.	7,700	12,800	3,200
Fiber stress, lbs. per sq. in.	6,100	9,900	2,660
E, 1,000 lbs. per sq. in.	1,860	2,410	1,390
Maximum load:			
Total load, lbs.	9,100	16,600	2,400
Fiber stress, lbs. per sq. in.	7,200	10,250	3,220
Maximum shear developed, lbs. per sq. in.	450	800	320

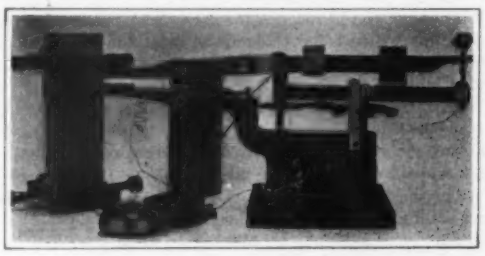


Fig. 1.—Micrometer compressometer for compression tests of timber.

Fig. 2.—Apparatus and type of specimen used for longitudinal shear tests of timber.

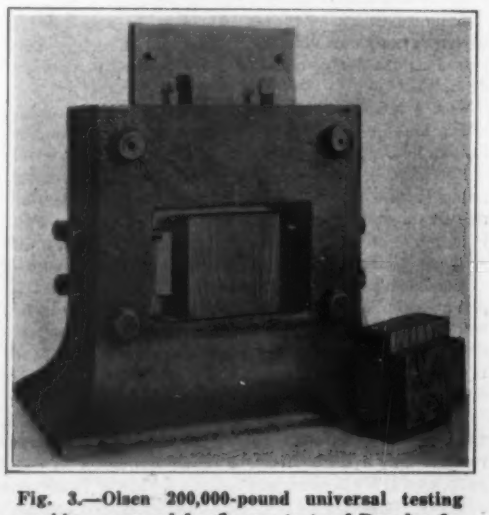


Fig. 3.—Olsen 200,000-pound universal testing machine arranged for flexure tests of Douglas fir.

TABLE 2.

LONGITUDINAL COMPRESSIVE STRENGTH. DOUGLAS FIR.

Quantity	Average	Maximum	Minimum
Dimensions:			
Section, in.		2.0 x 2.2	1.6 x 1.9
Total length, in.	8.0	8.1	7.8
Gauge length, in.	6.00	6.00	6.00
Number of rings per linear in.	15	30	5
Weight, as tested, lbs. per cu. ft.	35.2	46.0	28.5
Sapwood, per cent.	2.3	50.0	0
Elastic limit:			
Total load, lbs.	9,500	17,000	3,100
Strength, lbs. per sq. in.	2,470	4,250	850
E, 1,000 lbs. per sq. in.	3,420	5,250	1,500
Crushing load:			
Total load, lbs.	27,700	35,750	13,000
Strength, lbs. per sq. in.	7,040	9,200	3,400

3. *Longitudinal Shear.*

The specimens were sawed from tested floor joists and from 2 x 4 inch wall studding. The type of specimen and shearing apparatus used are shown in Fig. 2. The specimen is bolted in place so that the top surface of its projecting lip comes completely under the sliding plunger. The lip is sheared by applying compression at the top of the plunger. The shearing area of lip was 2 x 4 inches. One hundred and forty-seven tests were made, using a Riehle 100,000-pound testing machine. All specimens failed suddenly. Only maximum loads were noted. Table 3 gives a summary of the results.

TABLE 3.

LONGITUDINAL SHEARING STRENGTH. DOUGLAS FIR.

Quantity	Average	Maximum	Minimum
Dimensions:			
Shearing area, in.		2.1 x 2.9	1.7 x 3.0
Maximum load:			
Total load, lbs.	7,670	12,050	2,080
Shearing strength, lbs. per sq. in.	1,310	2,350	450

REDWOOD TESTS.

1. *Longitudinal Compression.*

The specimens were prepared by squaring the ends, the sides being left rough as originally sawed. Thirteen tests were made on pieces 3 x 4 inches and 4 x 4 inches in section and from 17 to 27 inches long, using an Olsen 200,000-pound universal testing machine. Compressive strains were read for load increments of 4,000 pounds by the same method as in the tests of Douglas fir.

The elastic limit and coefficient of elasticity were determined from stress-strain diagrams. All specimens showed a rather well defined elastic limit. Table 4 gives a summary of the results of redwood compression tests.

TABLE 4.

LONGITUDINAL COMPRESSIVE STRENGTH.
REDWOOD UNDERPINNING.

Quantity	Average	Maximum	Minimum
Dimensions:			
Section, in.		4.0 x 4.0	2.8 x 3.7
Total length, in.	22.9	27.2	17.3
Gauge length, in.	21.5	24.0	13.6
Number of rings per linear in.	22	60	18
Weight, as tested, lbs. per cu. ft.	29.8	32.1	26.7
Sapwood, per cent.	.3	2	0
Elastic limit:			
Total load, lbs.	58,000	70,500	39,900
Strength, lbs. per sq. in.	4,600	5,700	3,500
E, 1,000 lbs. per sq. in.	1,450	2,040	950
Crushing load:			
Total load, lbs.	68,000	88,450	45,000
Strength, lbs. per sq. in.	5,400	6,350	4,350

CONCLUSIONS.

The number of tests made was not large enough to justify any sweeping conclusions. However, a large number of tests made on material from just this source, which was the only one available at the time, would not have added materially to the value of the results.

A comparison of averages from the above test results with those given in Table 2, page 21, U. S. Forest Service Bulletin 108, on similar timber air seasoned for two years, shows the following facts:

1. Small pieces of the long seasoned Douglas fir without defects are 490 pounds per square inch stronger in longitudinal shear than two-year air-seasoned material which has an average resistance of 822 pounds per square inch. This represents an increase in shearing strength of about 60 per cent.

2. The modulus of elasticity in bending for the long seasoned Douglas fir is 20 per cent higher.

3. The fiber stresses at the elastic limit and at the maximum load for the long seasoned material are respectively about 30 per cent and 13 per cent higher.

4. The maximum crushing strength in compression longitudinally is 40 per cent higher for the long seasoned Douglas fir, but its elastic limit is 30 per cent lower.

5. The longitudinal crushing strength of the long seasoned redwood is 25 per cent greater.

* From the *Bulletin* of the Department of Civil Engineering Testing Laboratory.

Elastic Concrete Railway Ties

By Dr. Alfred Gradenwitz

In view of the rapid strides made of late years in the construction of railway rolling stock, especially locomotives, it is a matter of surprise that permanent ways should have remained practically unaltered. Apart from wooden ties, which still keep their original form, iron ties of various descriptions have been in use for about 50 years.

Now, wooden ties, while affording an elastic support for the rails and, on account of their heavy mass, an excellent means of bedding, show the drawback of a very short life, especially on lines where express trains are run. In spite of the more or less efficient methods of preservation devised of late years they are bound soon to lose their stability in regard to the screws and bolts, while in hot countries there is the additional risk of rotting and destruction by white ants. As far as the firmness and fastening of the rails is concerned, iron ties are more durable, although they can likewise be used only for a limited space of time. Moreover, these ties, in order to constitute a sure and steady support for the rails, would have to be made still heavier, which cannot be done for economic reasons.

Much hope has been attached to the use of armored concrete in the place of wood or iron, for the manufacture of railway ties. While iron-concrete ties are rather more expensive than wooden ones, but considerably cheaper than iron ties, and of a practically unlimited durability, they show the decided drawback of offering a very unelastic support to the rail and of being somewhat difficult to fasten to the latter. The attempt was therefore made to cement wooden blocks into the armored concrete ties, but this method failed to give the results expected from it, the wood itself not being sufficiently durable, while in the case of heavy fluctuations of temperature and moistures, warping the wood, the surrounding concrete would become fragile.

These drawbacks are avoided in the elastic concrete ties recently brought out by a German firm of manufacturers, which can be described as an ordinary armored concrete tie, where the wooden footing is replaced by elastic concrete blocks forming a homogeneous mass with the surrounding concrete so as to withstand any atmospheric influences. The special concrete used in this connection is a mixture of cement and asbestos fibres, soaked in water, which combines elasticity of wood with a remarkable strength.

The rails are fixed on "asbeston" ties in exactly the same manner as on wooden ties. Actual experience and tests made at Dresden Testing Office go to show that any nails, screws and bolts, even in the case of an intermittent strain, will adhere to the elastic concrete much more firmly than to wood. Moreover, the very considerable weight of asbeston ties (3 times that of wooden ties) warrants permanent firmness of the rails.

This new type of ties would seem to be especially suitable for use in the tropics and in countries where wood and iron are scarce. Moreover, its adoption should prove especially helpful in increasing the traveling speeds of trains in accordance with present tendencies.

Preparing concrete ties for laying track.

The Domestication of Animals

By W. F. Pycraft

How is it that the number of animals which man has succeeded in bringing into subjection, so as to minister to his needs, is so small, having regard to the immense number of species from which he may select? All told, they do not exceed six-and-twenty, and to make up this number we must include animals like the elephant, llama, camel, yak, and reindeer.

One reason, perhaps, is that this work of domestication was begun by our primitive forebears, who had but restricted resources for stock-keeping. Another is that only a limited number of animals thrive in captivity, and some will not breed in confinement. No one, again, has ever succeeded in subjecting the rhinoceros, even in zoological gardens, where other creatures no less formidable, like sea-lions, bears, lions, and tigers, have been more or less tamed. Other species which display more or less docility in captivity either breed but slowly or not at all; or they exhibit a peculiar fixedness of type—a conservativeness which the skill of the breeder has tried in vain to overcome. The ass, goose, and turkey afford good instances of this "conservativeness."

By courtesy of *The Illustrated London News.*

Well adapted for domestication—the eland.

This zebu was presented to the Zoological Gardens by the Duke of Bedford. European cattle are being crossed with the largest races of this animal, with a view to producing breeds of cattle immune from many tropical diseases fatal to ordinary cattle.

From time to time attempts have, indeed, been made to enlarge our stock of domesticated animals, yet so far with but little success. Some years ago, for example, an experiment was made to test the possibility of breeding that magnificent antelope, the eland, in captivity, so as to increase our food supply. It was hoped that it would afford us a welcome variant from beef and mutton, or, at any rate, that its flesh would be as easily procurable as venison. But, so far, nothing has come of these efforts. In like manner, all efforts at taming the zebra as an addition to our beasts of burden have proved unavailing. The camel and the two-humped (or Bactrian) camel have been domesticated for thousands of years—indeed, as wild animals have long since been extinct—yet there are no distinct breeds of these animals comparable to the various breeds of sheep and cattle.

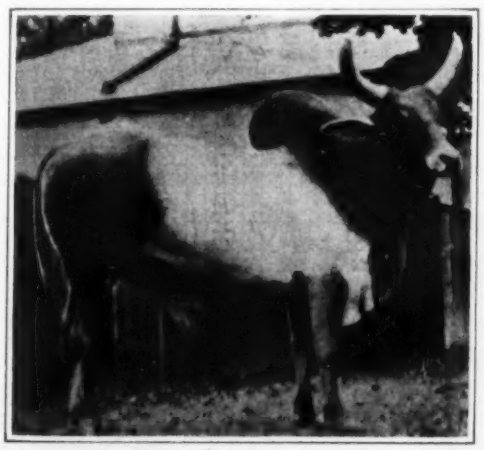
Realizing the hopelessness of further experiments in this direction, attempts during recent years have been made to utilize some of these intractable creatures in another way, and this by hybridizing, that is to say, by crossing them with domesticated animals. In Canada and the United States efforts are being made to cross domesticated cattle with the bison, or, as it is called there, but erroneously, the buffalo. So far, this experiment has been only fairly successful. The end desired in this case is increased size and greater stamina. Another interesting experiment is being made in regard to the humped cattle, or zebus. These are being crossed with European cattle, in order to produce a race of animals which will be immune to many of the tropical diseases so fatal to oxen of the ordinary breeds.

The latest experiments in breeding for commercial purposes are of a very different kind. Encouraged by the singular success of the ostrich-farmer, endeavors are now being made to breed some of the more valuable fur-bearing animals in captivity. The "blue-fox" was the first essay in this fur-farming industry, and it may be marked down as a very successful one. Indeed, when proper care is taken, finer skins can be put on the market than can be obtained from wild animals. And this for a very curious reason. The "blue-fox," which is the trade name for the Arctic fox, is in its best pelage in mid-winter, when its fur is longest. But the wild animal often very inconsiderately spoils his coat by his habit of basking in the mid-day sun. Not that the sun hurts the fur, but the warmth of the naimal's body melts the ice, which speedily freezes again, to inclose the tips of the longest hairs, so that when the animal rises these are plucked out and left behind. When it is kept in paddocks, this form of depilitation is impossible.

The "blue-fox" and the "white-fox" are different phases of the same animal. Skunk, mink, and sable are now to be made the subjects of similar experiments and it is fervently to be hoped that success will be attained, or these animals will speedily become extinct.

The skunk, as everybody knows, has the power of dispersing a fluid that has a particularly vile odor, and is possessed of a singular pertinacity. It is ejected with great force and precision from two large glands placed at the base of the tail. This power insures for its owner respectful treatment, both from man and beast. It made skunk-farming a very uncertain joy till some genius hit on the happy idea of removing the glands from the young animals; they are in no wise the worse for the deprivation, and their guardians are enabled to go about their work with confidence.

If the chinchilla and the egret can be added to this list, then the breeder will indeed have earned the gratitude of naturalists the world over. But the prospects of success are small indeed.—*Illustrated London News.*



By courtesy of *The Illustrated London News.*

Crossed with European cattle to produce a breed immune from certain tropical diseases—a zebu.

The photograph shows a bull eland chewing the cud. The eland is the largest and most inoffensive of all the antelopes, and, therefore, well adapted for domestication. The lopes, and, therefore, well adapted for domestication. The great dewlap, or fold of skin, hanging down from the neck, should be noted.

The Adaptation of Kerosene to Gasoline Engines*

By the Injection of Water

By G. A. Richter and B. L. Pierce

It is well realized at present that unless a suitable substitute is found for gasoline as a gas engine fuel, industrial progress in this field of power generation will not only be hampered but actually driven back. The problem as it stands before us to-day does not so much demand that we discover an entirely new calorific agent, as it does that we perfect methods of utilizing in a satisfactory manner other common fuels which are both cheaper and just as suitable as gasoline.

Probably the most universally proposed substitute is kerosene. Although many attempts have been made in the past few years to adapt kerosene as a satisfactory fuel for gas engine operation, these attempts have until recently been conducted with comparatively few theoretical considerations. In the past few years, however, it has been realized that theory is absolutely essential in a systematic solution of a practical problem.

It was with this in view that the problem was attacked in the chemical engineering department of the Massachusetts Institute of Technology as a thesis last spring.

* From Research Laboratory of Applied Chemistry. Massachusetts Institute of Technology.

The investigators in this work confined themselves to a single phase of the problem, that of utilizing kerosene with special reference to water injection methods.

One of the most serious troubles experienced in connection with satisfactory application of kerosene is the prohibitive deposit of carbon which accumulates in the cylinders when working under conditions which demand great flexibility in speeds and loads. It is the formation of this carbon which must be eliminated before kerosene can be considered as a suitable substitute for gasoline.

Of the factors which influence such a deposit of carbon the phenomena of incomplete combustion and excessive cylinder heating appear to predominate. It is these sources of carbonization which water injection methods aim to prevent. The theoretical and practical effects which such methods introduce are numerous and somewhat complicated.

Injecting water with the kerosene introduces several factors which bear direct influence on the carbon deposition:

(1) It reduces the cylinder temperature.

(2) The thin film of moisture which forms on the cylinder walls affords a very poor surface for carbon to deposit.

(3) The formation of steam in the cylinder exerts a loosening effect upon any carbon deposited and allows it to be blown mechanically out through the exhaust.

(4) We should get a less violent explosion and therefore prolong the life of an engine.

It is to be noted here that in the actual experimental work all of these effects were very noticeable.

The apparatus used to carry out the investigation consisted of a single cylinder, 4-cycle engine direct connected with a shunt generator. The engine was rated at 5½ horse-power at 650 revolutions and maintained a 3 per cent regulation.

The method which was employed in injecting the water is unique and original as far as known. This device consisted of a jacketed intake pipe (as shown in the diagram) terminating below in a T connection which is fitted with elbows. Only the intake proper was jacketed. A carbureter was fitted into each of the two elbows with the idea of injecting both the kerosene and the water by means of respective vaporizers. A Planhard carbureter was used for the kerosene and a Venturi for the water. The intake jacket was maintained at a temperature of about 50 deg. Cent., by circulating water which was heated by the exhaust.

Preliminary comparative runs were first made with gasoline as a fuel and the apparatus set up as described. A second set of runs was made with kerosene alone and finally water injection methods were employed.

The graphical representation of the results obtained

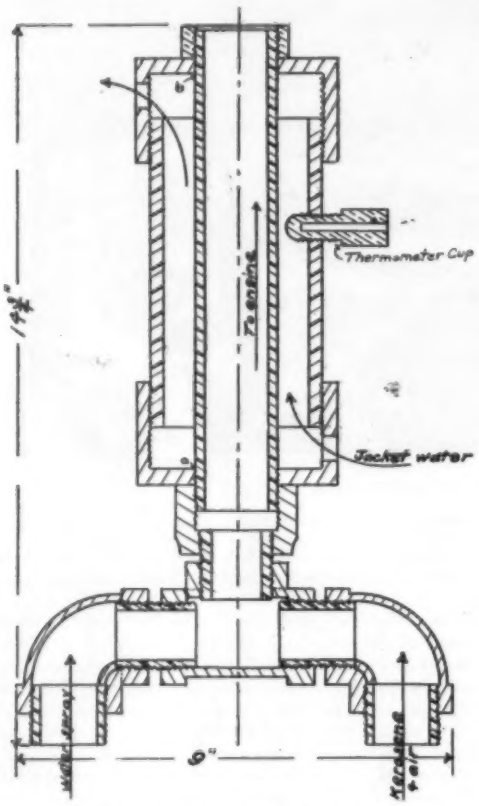


Fig. 1.—Water-jacketed intake.

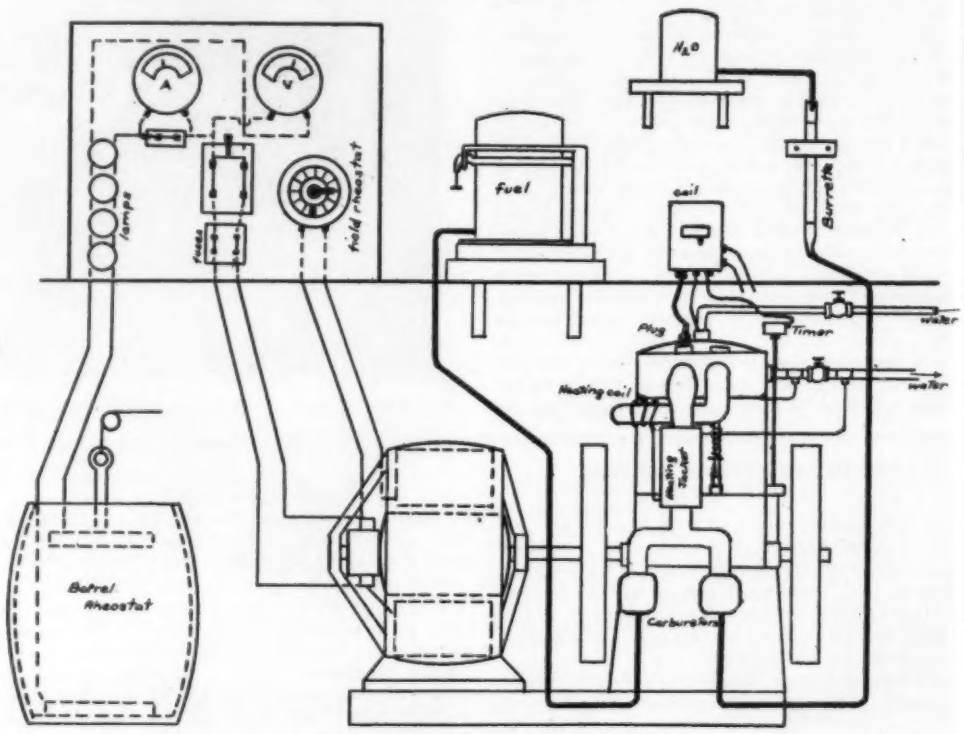
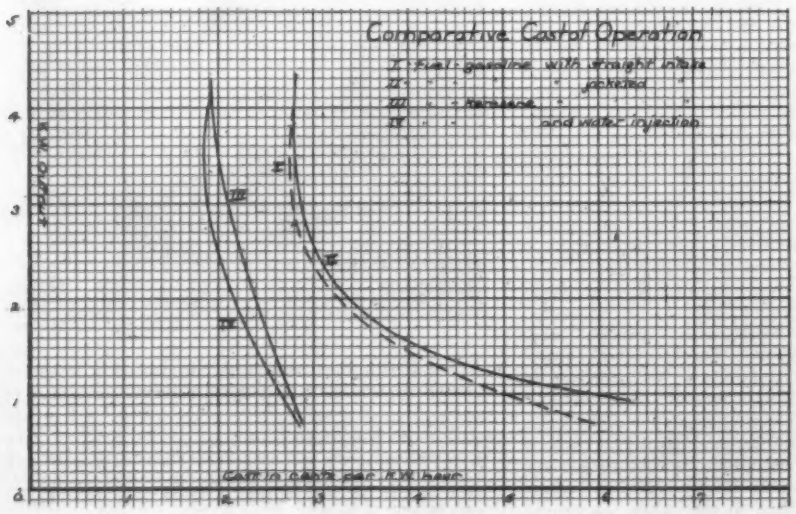
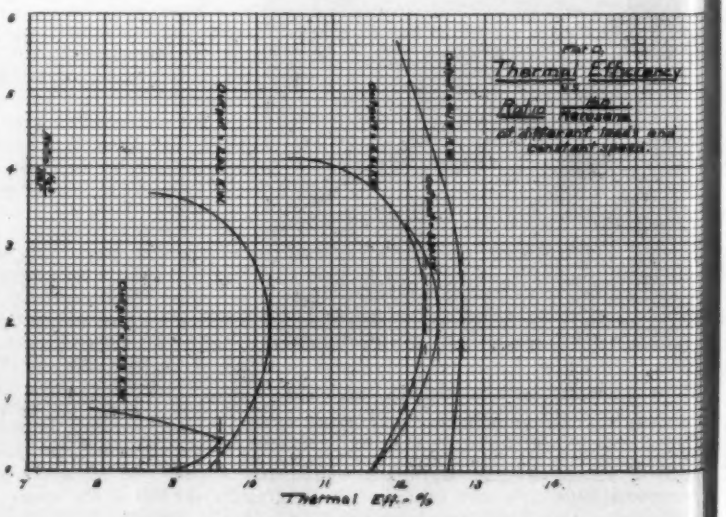


Fig. 2.—General layout of apparatus.


Comparative Cost of Operation
I. Fuel-gasoline with straight intake
II. " " " jacketed
III. " kerosene "
IV. " " and water injection
K.W. Hours
Cost in cents per K.W. hour

Plot 1.—Comparative cost of operation.



Plot 2.—Thermal efficiency and water ratio.

by these modifications in operation are self explanatory. Plot 1 indicates the comparative cost figure for the cases in question. The material decrease in cost realized when the kerosene is employed as fuel is apparent. The further decrease in cost effected by water injection is also noticeable.

Evidently these curves concern merely the comparative efficiencies and indicate in no manner the degree of carbonization realized.

It was noticed that the percentage of water in the fuel mixture influenced to a material extent the efficiency of the engine. The relationship between efficiencies observed and percent of water employed is shown in a striking manner by Plot 2. A curve was constructed for each of a series of loads. At each successive load it was found that a maximum efficiency was observed when the ratio of water to kerosene was equivalent to 0.22 by weight.

Using this most favorable percentage of water in the fuel mixture, a run was made to establish an efficiency curve to compare with a corresponding curve for a case where kerosene alone was employed. The result of this comparison is pictured in Plot 3. It is to be noted here that below and above definite outputs, there is no gain in efficiency realized by water injection.

In order to determine what quantitative effect the water had upon the carbon deposition within the cylinders, a number of longer runs were made, using the different fuel mixtures under similar conditions. In the run where kerosene alone was employed, normal conditions were maintained as nearly as possible and incomplete combustion was avoided as much as possible by control of the carbureter adjustments through exhaust observations.

In the water injection experiments, the water percentage which gave most efficient results in the previous experiments was employed. This most favorable ratio of water to kerosene as stated above was determined as 0.22. In each of the comparative runs from three to five changes in loads were used so as to approximate flexible operating conditions. The rate of carbon deposition was measured by weighing a representative portion of the valve cap before and after the run and recording the result as grammes of carbon per horsepower hour of operation.

Check results under identical conditions of operation gave the very surprising result that by means of water injection 82 per cent of the carbonization originally due to the kerosene had been eliminated.

Observations taken throughout the run showed that the presence of water in the charge had with the same amount of water circulation cooled the walls of the cylinder very appreciably. A mechanical loosening of the carbon from the cylinder was very evident in the exhaust gases. Moreover, such an introduction of water had not only prevented the formation of appreciable carbon but had also loosened and removed the greater part of the deposit which had accumulated while operating on kerosene alone.

A further step was taken to determine whether or not the presence of some oxidizing agent in the water would have any additional effect in preventing a carbonization of the cylinders. The material employed for this purpose was one which would leave no residue in the cylinder; such is a 25 per cent solution of ammonium nitrate. Analogous experimentation demonstrated that a further prevention was effected. A representative run showed a decrease of carbon deposition over the pure kerosene amounting to 88 per cent.

The results which were obtained in the above investigation appeared to be clear and convincing in every particular. The conclusions drawn are based on facts. The explanations offered for the observed phenomena are derived from theory. In each case theory and fact seem to coincide perfectly.

A correlation of the conclusions deduced are assembled:

(1) Kerosene as a fuel cannot be employed as such under the conditions investigated because of excessive cylinder carbonization.

(2) The injection of water with kerosene does increase the thermal efficiency appreciably when the ratio of water to kerosene is maintained at approximately 0.22.

(3) Absolute control of this ratio is not necessary as this maximum efficiency remains practically constant for several points to either side.

(4) The field advantageously effected in efficiency by water injection is limited from one third to full load for the engine in question.

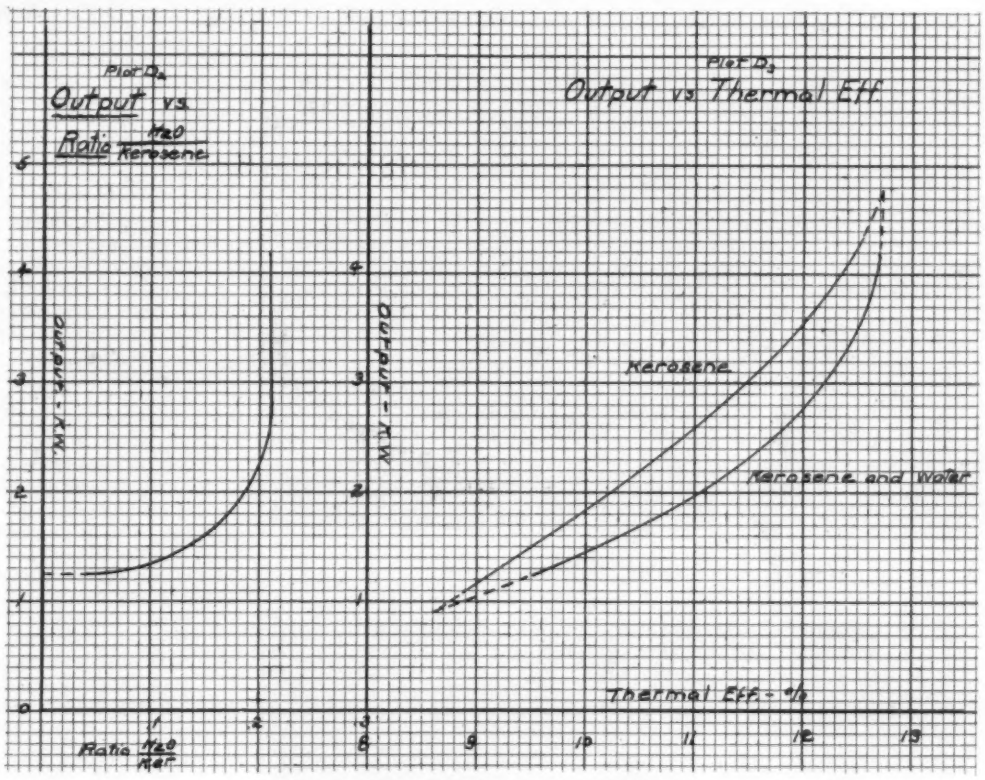
(5) Cylinder carbonization is decreased 82 per cent by injecting water with kerosene.

(6) An oxidizing solution of ammonium nitrate increases this value to 88 per cent but this added decrease in carbonization would not warrent its use for such work.

(7) The carbonization occurring with kerosene when water is injected into the cylinder is not objectionable.

(8) Spark plugs with long points appear to be more satisfactory than those with short points when kerosene is used.

(9) A water jacketed intake heated to a temperature of 60 deg. Cent. is sufficient to give satisfactory carburetion with kerosene.



Plots 3 and 4 output, water ratio and efficiency.

The Forging and Falsification of Postage Stamps*

By V. J. Baumann

The civilized world annually uses 30 billions of postage stamps, which have an aggregate face value of more than 1 billion dollars, and require the labor of 300,000 persons for their production, distribution and cancellation.

Postage stamps are often employed as a substitute for cash in the payment of small sums, and the temptation to forgery springs chiefly from this practice.

The falsifications are of two kinds. The first is forgery, in the strict sense of the word, i.e., the production of counterfeit or imitation stamps. The second consists in obliterating the cancellation marks of genuine stamps so that the stamps can be used again.

Neither of these frauds is very difficult to perpetrate in the present state of technical science. The enormous production and cheapness of postage stamps require comparative simplicity in design, ink, paper, etc., so that passably good imitations can be made without the employment of very complicated machinery or processes. Cancellation marks can be removed by various methods, and in many cases their removal is facilitated by the imperfect manner in which the cancellation has been performed, owing to the rapidity with which the stamps are cancelled and the variability of their position on the postal matter, it frequently happens that the impression is very light, or covers only a small part of the stamp, or even misses it entirely. These imperfections are especially likely to occur when cancelling machines are used, and the proportion of imperfectly cancelled stamps increases with the increasing employment of such machines.

The prevalence of any sort of crime depends upon the incentive, or possible profit, the difficulty of accomplishment, the risk of detection and the severity of the penalty. In counterfeiting postage stamps, at the present day, the difficulties are rather social than technical, and the strongest deterrent factor is the impossibility of producing and disposing of the counterfeits without the aid of confederates, each one of whom adds to the danger of detection.

The work of the stamp washer is far easier and safer. It can be carried on extensively without confederates, and the product can never be recognized as a forgery, which, indeed, it is not. This circumstance makes it much easier to dispose of washed stamps than of counterfeits, even the best of which can always be detected when suspicion has been directed toward them. Furthermore, the counterfeit stamp is a permanent evidence of crime, while the washed stamp shows no trace of the treatment that it has undergone. Even if the stamp washer is detected and convicted, his punishment is much lighter than that of the counterfeiter, who is punished as severely as the false coiner and the banknote forger.

The stamp washer enjoys an additional advantage in the simplicity of his apparatus. The counterfeiter requires presses, engraved plates, special paper and ink, a workroom and considerable capital. The stamp washer needs none of these things. He can start with nothing and can openly make the public serve his purpose.

The newspapers often print touching appeals purporting to emanate from some minister in Holland, for cancelled postage stamps which are to be devoted, in some mysterious way, to the accomplishment of some charitable purpose. This is the purpose:

Every large accumulation of cancelled stamps contains many stamps that are cancelled very imperfectly or not at all. If the proportion of entirely uncancelled stamps is large enough, a good profit can be made by merely sorting them out.

Again, it is possible to produce an entirely uncancelled, unwashed and apparently perfect stamp by laying a stamp cancelled in one corner only on another stamp of the same kind which bears no cancellation mark in the corresponding corner, tearing off both corners, and attaching the clean corner to the clean stamp. Even large cancellation marks, however, can be removed with little difficulty. A German postal official, to whom a lot of stamps cancelled with various inks was submitted, returned every one in absolutely clean and perfect condition.

In accordance with the difference in race traits the production of counterfeit stamps flourishes especially in southern, and stamp washing in northern countries.

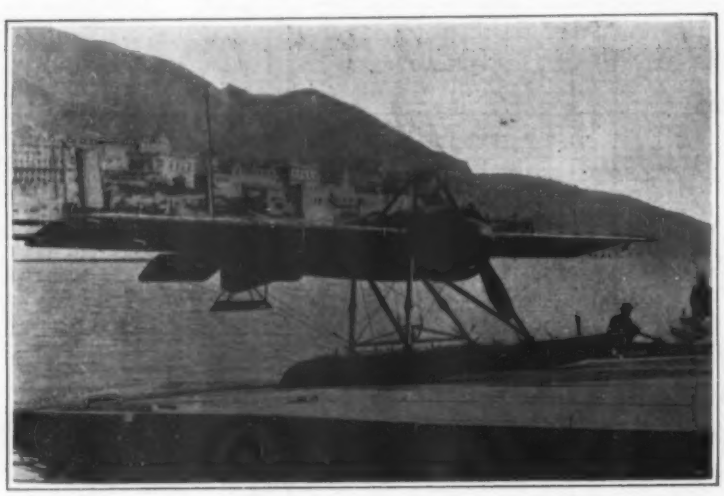
It is an astonishing fact that the (German) post-office has never even attempted to estimate the enormous loss which it must suffer from these criminal practices, although a fair estimate could easily be obtained by keeping an account of the number of cancellations of stamps of a given denomination and comparing the total with the number of stamps sold. Perhaps the postal authorities are afraid of the probable result of such an inquiry.

This loss could be eliminated by the abolition of postage stamps and the universal employment of the postal stamping machine, which imprints upon the letter or parcel the amount charged for postage, and the place, day and hour of printing. It would be useless to counterfeit such impressions by means of unauthorized machines, as matter thus stamped could not find its way into the mails without collusion between large mailing concerns and a number of postal employees. The stamping machine also registers the number and money equivalent of the impressions made by it. Even a rough system of weighing at each post-office, therefore, would detect the presence of any considerable quantity of fraudulently stamped matter, as the corresponding amounts would not appear in the records of the authorized machines attached to that of

* Abridged translation prepared for the SCIENTIFIC AMERICAN SUPPLEMENT from *Die Welt der Technik*.

The Nieuport-Dunne biplane, Nieuport single-seater and two-seater.

Deperdussin two-seater hydro-monoplane.



Deperdussin one-seated hydro-monoplane.

Monoplane treated with emaillite to render it invisible at moderate heights.

Tail and propeller of Borel military type.

H. Farman mono-biplane.

The Paris A tical

The Fifth "International" Exhibition clusively

By

THE "Fifth International Exhibition of Aerial Locomotion," opened on December 5th, occupied the Grand Palais until Christmas. The decorations as usual were very elaborate. With a few exceptions the improvements over last year were confined to detail, the machines as a whole being very well constructed. Of the 18 makes shown all are French except the British Bristol. A military type is featured on nearly every stand proving, if proof were needed, that the aeroplane is preëminently a war machine.

On entering the Salon the first object seen is one of the two armored gondolas of the new Astra-Torres dirigible of 23,000 cubic meters. Four 250 horse-power engines are expected to give a speed of 60 miles an hour. Each engine drives, through bevel gearing, a large propeller arranged outboard and suitably stayed. Wireless telegraphy and a Hotchkiss mitrailleuse are included in the equipment.

The Clement-Bayard firm shows two monoplanes, a single and a two seater, both with bodies armored to the rear of the wings. The chassis consist of wheels only, skids having been abandoned.

Of the three monocoques on the Deperdussin stand the Gordon Bennett Cup winner is perhaps the most interesting. Its span of 21 feet 6 inches makes necessary only four stay cables to each wing. The second exhibit is the machine with which Gilbert so nearly won the Pommery Cup, flying from Paris to Putnitz (Germany), 970 kilometers (602 miles) in 5 hours 11 minutes. Two extra fuel tanks were fitted to the sides of the body for this flight. For 1914 these tanks will be a standard feature, being incorporated in the body which will be widened. The hydroavion has its wings cut away at the junction with the fuselage to give the pilot, who sits behind the passenger, better vision. The Régy tractor has, of course, its blades armored. The floats are of Tellier construction.

Two types of Caudron biplanes are on view, both having the characteristic blue tinted planes. In the 100 horse-power Gnôme hydro the pilot and passenger, contrary to usual Caudron practice, are placed in front of the planes, the motor propeller being at the rear. The motor is geared down to give about 900 revolutions. Each of the two Fabre floats has a rectangular space cut out to give room for a wheel permitting the hydro to start or land on the ground. In the 80 horse-power army biplane the skids form the lower members of the tail outriggers, being therefore very long. The pilot and passenger are seated tandemwise behind the motor. The angle of the monoplane tail is variable. The Caudron wings have extreme flexibility; both rows of uprights being very near together permits the rear half of the plane to adapt itself automatically to variations in wind pressure

The Franco-British Aviation Company has the manufacturing rights for the Curtiss, d'Artois, and Lévêque flying boats, all similar in their general conception. Only the last named craft is shown. The pilot and passenger sit in a hull extending the entire length of the machine. This hull, acting as a central float is divided into 8 watertight compartments. At the extremities of the lower plane

Blériot 1914 armored single-seated monoplane.

Blériot biplane, view showing body and landing chassis.

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are placed small auxiliary floats. The 100 horse-power Gnôme is mounted high up between the planes.

Two monoplanes occupy the Ponnier stand, their all-steel biplane not being shown. The Type Course is the smallest machine in the show, having a surface of only 82 square feet, 10 square feet less than their Gordon Bennett model. Also the pylone has been replaced by two tiny masts, each carrying two cables, one to each wing. The warping mechanism is entirely enclosed in the fuselage. The so-called "Avion de Cavalerie" is a single seater having 139 square feet surface, weighing only 473 pounds empty. With a useful load of 325 pounds it has a speed range between 43 and 78 miles per hour, and can climb 1,000 meters (3,270 feet) in 2 minutes 30 seconds.

Henry Farman shows a new mono-biplane in which the body is placed flush with the top plane. The lower plane, of only 13 feet span, is placed very near the ground, the landing chassis consisting simply of a disk wheel at each extremity. Maurice Farman stages a new hydro-biplane with no front elevator.

Two R. E. P. monoplanes are shown which possess no new features. The well known system of autogenous steel welding is still employed for the fuselage construction.

A new-comer is the de Beer monoplane. It follows standard lines except that the angle of incidence of the wings can be varied in flight.

The Goupy firm exhibits biplanes—a single and two seater—in which their familiar system of staggared planes is incorporated. In the two seater the pilot is placed behind the passenger. The chassis of the single seater, the smallest biplane in the show, is composed of two wheels only, no skids being used.

On the Borel stand are three monoplanes, including a hydro, the floats of which are attached to the rear chassis struts flexibly, permitting 2 inches play. The observer is placed ahead of the pilot and has good vision, as the front of the wings is cut away in proximity to the body. The standard two-seated monoplane has a chassis of two wheels and rudimentary skids, otherwise it is similar to the hydro. The novelty is the Military Type which recalls the Tatin Paulhan in having the propeller at the extreme rear, driven through a shaft supported at intervals by ball bearings. The Gnôme motor, cooled by louvres in the body, is placed behind the seats. The pilot sits in the extreme bow and has a mitrailleuse which he can work in his spare time. The observer is between the pilot and engine. A more logical arrangement would be to have the position of the pilot and passenger reversed.

Paul Schmitt exhibits a large biplane the planes of which have their incidence variable from 0 to 12 degrees.

The most interesting machine on the Morane-Saulnier stand is the Type Parasol slightly changed since its appearance at Rheims. The rear of the plane above the passenger is now cut out, giving him a better view. The other two exhibits are the standard one and two seaters, presenting nothing new.

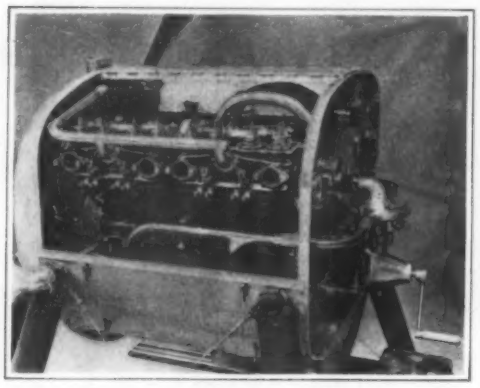
Borel hydro-monoplane.

Bréguet biplane.

Deperdussin stand. Gordon Bennett winner at left.

The Morane-Saulnier monoplane.

	Make.	Type.	No. of Seats.	Dimensions. Span. Upper Plane.	Span. Lower Plane.	Length.	Surface.	Weight. Machine.	Weight. Useful Load.	Motor Make & H. P.	Screw. Make.	Screw. Propellor (P) Tractor (T)	Price.
				ft.	ft.	ft.	sq. ft.	lbs.	lbs.				$
1	Bathiat-Sanches	Biplane	3	42.8	41.	32.9	492	1,210	605	De Dion 80	Régy	P	4,700
2	"	Monoplane	1	29.2	....	23.2	171	648	330	Rhône 60	Régy	T	4,200
3	Blériot XI, 1914	Monoplane	1	29.2	....	25.5	161	583	330	Gnôme 60	Chauvière	T	4,400
4	" XI-2	Monoplane	2	33.9	....	27.5	203	737	550	Gnôme 80	Chauvière	T	6,000
5	" XI-2	Hydro-monoplane	2	36.2	....	29.5	256	1,100	550	Rhône 80	Régy	T	7,000
6	" 43	Monoplane	2	33.1	....	22.	203	770	605	Gnôme 80	Chauvière	T	.....
7	" 39	Monoplane	1	33.1	....	20.2	203	968	....	Gnôme 80	Chauvière	T	.....
8	" 40	Biplane	2	41.6	....	30.	406	858	550	Gnôme 80	Chauvière	P	.....
9	Borel	Monoplane	2	39.4	....	24.6	193	616	616	Gnôme 80	Chauvière	T	5,000
10	"	Hydro-monoplane	2	39.4	....	29.5	203	1,188	616	Gnôme 80	Chauvière	T	6,000
11	" (military)	Monoplane	2	....	....	....	....	....	....	Gnôme 80	Régy	P	.....
12	Bréguet	Biplane	2	50.8	41.3	33.8	535	2,000	770	Salmson 130	Chauvière	T	10,400
13	Bristol	Biplane	2	36.	36.	28.2	406	946	660	Gnôme 80	Bristol	T	7,000
14	Caudron	Biplane	2	37.4	22.5	23.9	300	788	605	Rhône 80	Régy	T	.....
15	"	Hydro-biplane	2	47.9	30.2	26.9	407	1,430	770	Gnôme 100	Régy	P	.....
16	Clement-Bayard (armored)	Monoplane	1	30.2	....	24.6	171	704	440	Clerget 80	Chauvière	T	.....
17	" (armored)	Monoplane	2	....	....	....	193	....	....	Clerget 80	Régy	T	.....
18	De Beer	Monoplane	2	....	....	....	193	704	660	Anzani 80	Normale	T	.....
19	Deperdussin (racing)	Monoplane	1	21.6	....	18.9	96	990	418	Gnôme 160	Chauvière	T	10,000
20	"	Monoplane	1	29.4	....	19.7	148	1,100	418	Rhône 160	Chauvière	T	9,000
21	"	Hydro-monoplane	2	44.6	....	29.	300	1,375	770	Gnôme 100	Régy	T	8,400
22	Goupy	Biplane	1	19.7	19.7	18.	128	649	550	Gnôme 80	Chauvière	T	4,400
23	"	Biplane	2	42.6	29.5	26.2	321	858	990	Gnôme 80	Chauvière	T	6,000
24	Farman (Henry)	Biplane	2	39.4	13.1	23.	267	704	550	Gnôme 80	Chauvière	P	6,600
25	" (Maurice)	Hydro-biplane	2	50.8	32.8	39.4	556	1,320	660	Renault 70	Chauvière	P	6,600
26	Léréque	Hydro-biplane	2	39.7	25.5	25.3	278	1,034	858	Gnôme 100	Chauvière	P	.....
27	Morane-Saulnier	Monoplane	1	30.2	....	20.3	150	660	590	Gnôme 80	Chauvière	T	6,100
28	"	Monoplane	2	33.5	....	20.3	161	693	660	Rhône 80	Chauvière	T	6,200
29	" (Parasol)	Monoplane	2	33.5	....	20.3	161	700	660	Gnôme 80	Chauvière	T	6,400
30	Moreau (Aerostable)	Monoplane	2	41.	....	32.8	241	1,056	550	Gnôme 80	Chauvière	T	6,400
31	Nieuport XI	Monoplane	1	29.5	....	21.3	155	620	352	Rhône 60	Régy	T	5,000
32	" X	Monoplane	2	40.4	....	27.1	247	880	....	Clerget 80	Régy	T	6,200
33	" (armored)	Monoplane	2	....	....	....	....	....	....	Gnôme 160	Chauvière	T	.....
34	" (Dunne)	Biplane	2	48.4	48.4	22.1	535	935	....	Gnôme 80	Chauvière	P	7,000
35	Ponnier (racing)	Monoplane	1	19.7	....	17.9	82	715	....	Gnôme 160	Chauvière	T	12,000
36	" DVIII	Monoplane	1	30.	....	17.2	139	473	352	Rhône 60	Levasseur	T	5,600
37	R. E. P.	Monoplane	1	33.5	....	21.9	171	825	440	Gnôme 80	Chauvière	T	.....
38	"	Monoplane	2	38.	....	24.6	214	913	550	Rhône 80	Chauvière	T	.....
39	Schmitt	Biplane	3	57.7	46.3	32.8	524	1,210	1,210	Gnôme 160	Chauvière	T	12 000



Lawrence-Moulton 8-cylinder 200 horse-power motor.

The Blériot firm carries over the XI-2 two seater from last year, but it is supplemented by Type 43, a new monocoque design showing Deperdussin influence. A single-seater monocoque, armored, has also just made its appearance; a fuselage of this is shown. The XI-2 hydroavion has a very flexible chassis allowing 14 inches play to each float, separately. This is accomplished by using deformable triangles as on the land machines. The new Blériot biplane is an extremely neat piece of work, being of steel throughout with the exception of the wings. The landing chassis is a clever application of the castor principle permitting easy steering on the ground. The monoplane tail has twin elevators with a rudder between them.

The Bréguet hydro has a large central float with two auxiliaries at the side. An interesting point is the radiator, which replaces the upper plane over the fuselage. Being shaped to the wing section it offers no extra resistance. A three-seated fuselage is shown equipped with a wireless system capable of sending 125 miles.

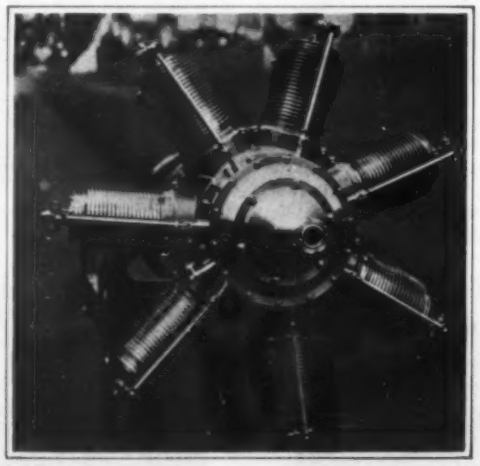
The Moreau aerostable has its wings covered with the new form of Emaillite, rendering it invisible at 1,200 feet. The automatic stability device of the Moreau, operated by pendulum action of the two-seated car, can be thrown out of action when desired, the machine then being controlled in the customary way. One of the Moreau brothers recently flew with a passenger for 200 kilometers without touching the aileron or elevator control.

The Bristol tractor biplane is equipped with an ingenious bomb-dropper under the fuselage controlled by the observer. A dozen slender cylindrical bombs, fitted with dart heads and propeller apparatus exploding the charge through a time fuse, are arranged around a sighting tube.

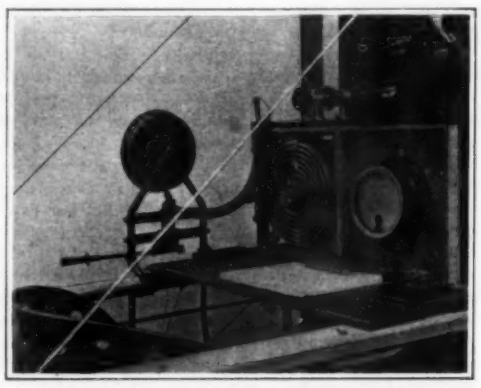
The Nieuport Company shows five machines, four monoplanes and the Dunne biplane for which the company has the French rights. As is well known, the Dunne is inherently stable by means of the V-shaped plan of its planes. Elevating and steering are effected by operating the ailerons in the same or opposite senses, the machine having no tail. The construction has been greatly improved since the machine was introduced into France, but the landing carriage is an obvious copy of that on the Blériot biplane. To insure better vision for the passenger in the standard two-seated monoplane, he is now placed ahead of the pilot. The one-seater shown marks a new departure for the Nieuport firm in having wing warping by hand instead of by foot. The wing spars on this machine are of steel. The three-seated army model has its body armored as far back as the rear wing spar. One of the two passengers who sit side by side behind the pilot can operate a mitrailleuse through a very small angle. It was impossible to obtain the dimensions of this machine, as the government had requested the makers to give no particulars. The last exhibit was the oil-stained winner of the Michelin Cup.

The French government has several carefully guarded stands containing kites, motor cars and trailers for aeroplane transport, traveling meteorological stations, etc.

The Brothers Seguin show a complete line of Gnôme motors including the 50, 60 and 80 horse-power, 7 cylinders; 100 horse-power, 9 cylinders; 100 and 160 horse-



Eighty horse-power single-valve Gnôme motor.



Wireless apparatus on Bréguet machine.

power, 14 cylinders; and 200 horse-power, 18 cylinders. There are also several examples of the new single-valve motor. It is made in two sizes—80 horse-power, 7 cylinders and 100 horse-power, 9 cylinders—with bore and stroke 110 x 150 millimeters instead of 124 x 140 millimeters as on the current 80 horse-power model. The gas is admitted through holes in the cylinder walls opened by the passing of the piston, instead of through an automatic valve in the piston head.

Opposite the Gnôme exhibit is shown the L. & M. motor designed and built by two Americans, Messrs. Lawrence and Moulton, in their factory near Paris. It is a V-type water-cooled engine with 8 cylinders, 120 x 165 millimeters bore and stroke. Each cylinder has one inlet and two exhaust valves, the auxiliary exhaust, a rotary valve, being at the bottom of the stroke thus insuring complete scavenging of the cylinder. Fresh air is forced into the crank case and cam chambers by scoops. A special radiator of 400 tubes cools the oil.

The Rhône rotating motors are shown in four powers, all with cylinders 105 x 140 millimeters. They are 80, 100, 160 and 200 horse-power, with 9, 11, 18 and 22 cylinders, respectively. This machine is distinguished by having both valves mechanically operated and being more economical than the Gnôme. Other rotating motors shown are the Clerget and S. H. K., the latter having an interesting type of double concentric valve.

The leader of the Anzani line is the new 200 horse-power, 20 cylinder radial motor. Ten-cylinder engines of 60 and 125 horse-power are also marketed. Renault and De Dion exhibit their V-type air-cooled motors, and Panhard shows a very neat water-cooled motor of the same type with each set of 4 cylinders in a block casting.

The Sudden Origin of New Types—I*

By Felix Oswald, D.Sc., B.A., F.G.S.

FORMERLY the opinion was generally held by comparative anatomists that simplicity of structure necessarily implies a persistence of the primitive organization of the race; this view is still not without some supporters at the present day. The theory, however, has not only proved unfruitful but has acted as a positive bar to the correct estimation of affinities and pedigrees in the organic world. It is by no means the least of the late Anton Dohrn's services to biology that he was among the first to make a stand against the view prevalent at the time, to the effect that organisms of relatively simple construction, such as Amphioxus or Ascidians, are necessarily archaic survivals or in any way represent the actual links in the ancestral chain of the higher

* *Science Progress.*

or more complicated forms of the same group. This older view was all the more alluring to the laity because it was so easy to comprehend, but every new discovery in the field of palæontology tends only to discredit it still further and to render the position of its supporters more and more untenable.

The comparative study of languages, which has furnished so many interesting parallels to the processes of organic evolution, can also supply us with a close analogy to the case under consideration. The English language which has spread so successfully all over the world is far simpler and less inflected than its ancestral Saxon of King Alfred's day; while Sanskrit, the oldest known type of the Indo-European group of languages, possesses the greatest number of inflections. In Chinese, no less than in English, inflections have fallen extensively into disuse owing to the gradual adoption of a fixed word-order and a multiplicity of particles, but it is obvious that the resulting simplicity by no means implies that these modern languages are archaic survivals.

The main distinction between primitiveness and simplicity of structure in an organism would appear to lie in its capacity for variation. A primitive type, that is to say an ancestral type, must *a priori* have been pre-eminently plastic and variable, otherwise it could not have given rise in the course of evolution to a divergent series of descendants. On the other hand, a modern existing animal or plant showing a marked simplicity of structure has evidently reached this condition by an extreme degree of adaptation to its environment, and it will be found on examination to be due to a process not so much of degeneration as of specialization by reduction from a more complicated condition.

Now it was noticed long ago by Isidore Geoffroy St. Hilaire[1] that when any part or organ is repeated many times in the same individual (e. g., the vertebræ in snakes, the arms of some starfishes, the stamens in polyandrous flowers, etc.) its number is variable; whereas this remains constant in cases when the same part or organ occurs in few numbers. In other words, multiple parts are extremely liable to vary in structure. The high variability, which is necessarily implied by the capacity of a primitive type to give rise to a series distinctly higher in the scale than itself, indicates that the first step requisite to start the beginning of this new series would seem to be the multiplication or repetition of some special part of its organization. This increase in the number of parts is correlated with an increased variability of the part or organ, and under the sifting influence of natural selection upon the numerous variation a greater efficiency and elaboration of the organ would be rapidly secured, leading to a correspondingly rapid rise and predominance of the new type.

Strong support of this view has recently been furnished by the investigations of Wieland[2] on American *Bennettiteæ;* his results have been still further amplified and pushed to their logical conclusions by Scott[3] and Arber.[4] In face of these remarkable discoveries is it no longer possible for systematists to lay stress on the simplicity of the trimerous flowers of Monocotyledons or the reduction shown by the flowers of the *Amentiferæ* or of other so-called *Apetalæ* as indicating primitive relics of the ancestral forms of flowering plants. Palæontology itself seemed to lend some countenance to the earlier view, which held the field for so long, for the earliest known remains of Angiosperms, occurring in the Neocomian of Portugal and the United States, were identified for the most part as members of the catkin-bearers, such as Myrica, etc.

Wieland's researches on the *Bennettiteæ* have clearly shown that the members of this group possessed strobilate flowers, which must have been closely allied in structure to those of the primitive Angiosperms, for they evidently stood very near to the direct line of descent. It is sufficient for the present purpose to adopt his generalized diagram of the flower which he considers to be typical of the *Bennettiteæ* or Pro-Angiosperms (as Saporta[5] with almost prophetic instinct named them at an earlier date on very insufficient material). Here, e. g., in *cycadeoidea dacotensis*, we find a conical axis or receptacle on which the ovules (separated from each other by bracts) are ranged in dense order. These are surrounded by a whorl of 18 to 20 stamen-bearing fronds, which in turn are enveloped by a hundred or more hairy, sterile bracts arranged in spiral phyllotaxis. The male fronds or microsporophylls each bear twenty pairs of alternate pinnæ, on which are ranged ten rows of sori or synangia (closely resembling the synangia of the eusporangiate fern Marattia), showing affinities with the fern-like Pteridosperms to a greater degree than the reduced and more specialized megasporophylls or ovules. It is, however, intelligible and only natural that the organs which are the most essential to the continuance of the race, i. e., the female elements, should have advanced more rapidly than the male organs; and, as a matter of fact, it is well known that the Pteridosperms had attained to the production of seeds at least as far back as the Carboniferous period. The great stride in advance that the *Bennettiteæ* had made upon the Pteridosperms was effected by the evolution of a strobilus, in which the male and female organs were grouped together and protected by spirally arranged foliar structures (a primitive perianth according to Arber[6]) foreshadowing the hermaphrodite flowers of Angiosperms. It will be evident from the principle already enunciated above that the very fact of a repetition of protecting bracts (or primitive perianth) as well as a repetition of the male and female elements (microsporophylls and megasporophylls) must have induced a high degree of variability in all these structures and in the resultant strobilus as a whole. In this connection it is of importance to note that the American *Bennettiteæ*, according to Wieland's researches, show a remarkable variety both of form and structure.

A most significant result of his observations is that the male and female elements are not matured at the same time. This protandry would appear, in Wieland's opinion, to indicate (as it does in the Angiosperms of the present day) the dependence of these primitive flowers on insect-visits for fertilization. The abundance of pollen or microspores produced by the pinnate microsporophylls renders it likely, as Arber (*op. cit.*) suggests, that pollen and not honey was the original attraction of these early flowers to insects. Dr. Scott[7] has in this connection remarked on the bright colors shown by living species of Cycas and Encephalartos; and it seems therefore not unreasonable to infer that these primitive flowers also displayed colors and laid themselves out for insect-visits. This entomophily must have been a most potent factor in the action of natural selection upon a plastic and variable group. The presence of protandry in itself implies a long-established succession of insect-visits to the ancestral *Bennettiteæ*, for it is a well-known law[8] that the primary effect of intercrossing is to enhance the size of the corolla, to give a preponderance to the androecium, and to cause protandry by checking the growth of the gynœcium. Now since this is already the state of things in the *Bennettiteæ* (excepting only that the numerous floral leaves are long rather than broad). It would follow as a matter of course that the agency of insect-visits must have been at work upon the ancestral forms for a considerable time previously.

Perhaps it might be traveling too far into the region of hypotheses to suggest that the insects, in their visits to the ancestors of the *Bennettiteæ* for the purpose of eating or collecting microspores (pollen), directly exercised a stimulus upon the strobilus, causing a greater flow of nutriment to this region of the plant and inducing an active multiplication or proliferation of its parts, which, as already indicated, is the necessary preliminary of variability. At any rate the phloëm in the peduncle of the Bennettitean strobilus greatly exceeds the xylem in thickness, and this is a clear indication of the heavy requisition which the very numerous reproductive organs made upon the supply of the necessary nutriment.

The reduction from an indefinite number of floral leaves to a pentamerous perianth must have occurred at a very early period, since pentamerism is so deep-seated a characteristic of Dicotyledons,[9] and the question naturally arises why *five* should have become the optimum, not a greater or a lesser number. The problem seems to be open to a plausible solution if we turn for a parallel to the early forms of Crinoids. Here the question is quite obviously one of obtaining the greatest economy of material consonant with the maximum area to be exposed by the food-gathering arms, which have also to inclose and protect a central vaulted dome, often prolonged into a high anal column, e. g., in Poteriocrinus, Botryocrinus. The number *five* in this case, and still more forcibly in the Blastoids, seems to me to be determined by the geometrical fact that the maximum plane-angle of a polyhedron is that of a pentagon, for the three angles of three adjacent hexagons cannot form a solid angle, while, on the other hand, four sides based on a square, or three sides on a triangle, would be quite insufficient to insure the complete protection or space necessary for the full development of the central dome of Crinoids. Now the same reason can be held to apply to the flower of the early Angiosperms, for the greater part of the flower of the *Bennettiteæ*, which stand so close to the parent-stock, is occupied (as already described) by a central column composed of innumerable megaspores or ovules, surrounded by a whorl of fern-like stamens, and by a more external envelope of spiral perianth-leaves. Since in both the flower and the Crinoid the same amount of reduction to the optimum number of *five* has taken place in the floral leaves and arms respectively, it seems only consistent to infer that in both cases the same cause has been operative, viz., the use of a minimum amount of material consistent with the maximum amount of inclosed space.

It has usually been held that floral pentamerism is a result of the $\frac{2}{5}$ phyllotaxis, which is so frequent in Dicotyledons; but since it has now been proved that whorled flowers (at any rate flowers with staminate whorls) occur in the unbranched or only slightly branched *Bennettiteæ*, and since free-branching was a habit coincident with the rise of Angiosperms, it appears to me at least conceivable, if not altogether demonstrable, that the $\frac{2}{5}$ phyllotaxis and the consequent free-branching may be the *result*, not the cause of the floral pentamerism. The possibility of this view is supported by Rendle's observations on a specimen of heather (*Erica cinerea*), in which the flowers were replaced by dark-red leaf-buds of about the same size as the flowers; in these the leaf-arrangement resembled that of the flower, *not* that of the foliage-leaves.

Dr. Scott[10] has cogently argued that evolution by reduction in the number of parts seems to have taken place with comparative rapidity and suddenness, so that it often "set in at a relatively early stage of evolution." Thus such groups as the *Amentiferæ*, with simple reduced flowers, may indeed be very ancient, though not primitive in the exact sense of the word.[11] While in some cases reduction may occur mainly as the result of the natural tendency of organisms to economize material, it seems to me not impossible that in the case of the early *Amentiferæ* it took place partly as a result of a migration to the Temperate zone of their ancestral types from the Tropics, where variability is always greatest owing to the increased rate of growth induced by heat,[12] and partly as a result of their becoming adapted to wind-pollination, owing to the presumable absence of the insects necessary for cross-fertilization.

Within comparatively recent times the catkins of the willows have reverted to pollination by insects; in order to attain this end the flowers now secrete honey and have become conspicuous by the increased yellow color of the stamens. It seems not improbable that the extraordinary variability of *Salix* may be in some way correlated with this abandonment of wind-pollination in favor of visits by insects, while the poplars, which stand nearest the ancestral type of the two genera Salix and Populus, retain the habit of anemophily and display none of the great variability of the willows.

With regard to the question of a reduction in parts being influenced by the necessity for an economy in materials, it is interesting to note that it is a distinct economy for the plant to have acquired the essentially Angiospermic character of the protective envelopment by the carpel of the ovule; for, as Arber points out, the chance of pollination is thereby increased, since the insect has only to leave the pollen on one part of the carpel. The same author indeed considers that entomophily by means of closed carpels will be found to be the real influence which called the Angiosperms into being.

The foregoing principle, which would seem now to be substantiated for flowering plants, viz., an increased variability and plasticity resulting from a repetition of similar parts, and a subsequent specialization by rapid reduction to an optimum, can be applied equally well to the animal kingdom. As Smith-Woodward[13] has succinctly observed, "throughout the evolution of the organic world there has been a periodical succession of impulses, each introducing not only a higher grade of life, but also fixing some essential characters that had been variable in the grade immediately below," and again that "the progress of the backboned land-animals during the successive periods of geological time has not been uniform and gradual, but has proceeded in a rhythmic manner." I will now endeavor to explain the nature of these "periodical successions of impulses," or "expression-points" of E. D. Cope, by the application of the principle of this paper to some of the main classes of animals.

(To be continued.)

[1] *Hist. Gen. et Part. des Anomalies de l'organization*, 1832.

[2] Wieland, G. R., A Study of some American Fossil Cycads. *Amer. Journ. Sci.* Ser. 4 (1899), (1901); and *American Fossil Cycads*, 1906.

[3] Scott, D. H., The Flowering Plants of the Mesozoic Age, etc., *Journ. Roy. Microsc. Soc.* April, 1907; *Studies in Fossil Botany*, 1909; - Adaptation in Fossil Plants, 1909.

[4] Arber, E. A. N., and Parkin, J., On the Origin of Angiosperms, *Journ. Linn. Soc.*, 1907.

[5] Saporta, G. de, *Plantes Jurassiques*, vol. iv. Paris, 1891.

[6] *Op. cit.* p. 58.

[7] *Journ. Roy. Microsc. Soc.* April, 1907.

[8] Henslow, Rev. G., *The Origin of Floral Structures*, etc. London, 1888.

[9] The fact of the *Bennettiteæ* possessing two seed-leaves is one of the strongest of the reasons for considering Dicotyledons to be the parent-stock of the Monocotyledons.

[10] Adaptation in fossil plants. Presid. Address, *Linn. Soc.* 1909.

[11] A striking instance of a remarkably rapid and early reduction is furnished by the Chelonians, for the earliest known example of this class, viz., from the Upper Keuper sandstone of Würtemberg, is a complete shell (2 feet long) of Proganochelys belonging to the peculiarly specialized group of the Pleurodira. Yet this Triassic form can not, geologically speaking, be very far removed from the ancestral Chelonian, considering that no reptiles are known in pre-Permian rocks.

[12] Blaringhem, L., *Mutation et Traumatisme*, etc. Paris, 1908.

[13] *Ann. Nat. Hist.* xviii. 1906; see also his Presid. Address, Geology, Brit. Assoc. 1909.

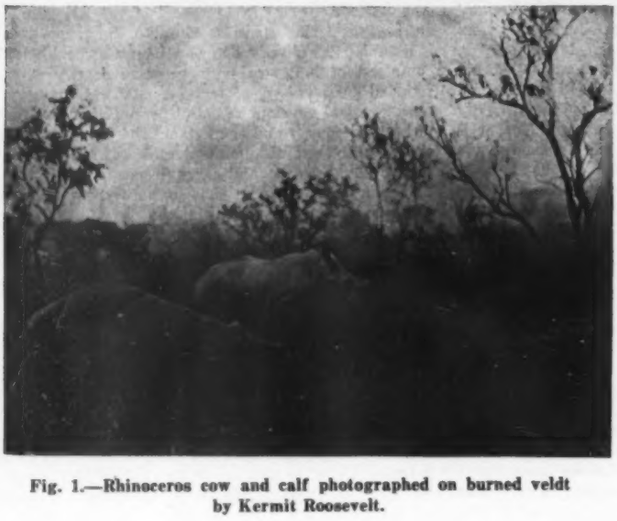


Fig. 1.—Rhinoceros cow and calf photographed on burned veldt by Kermit Roosevelt.

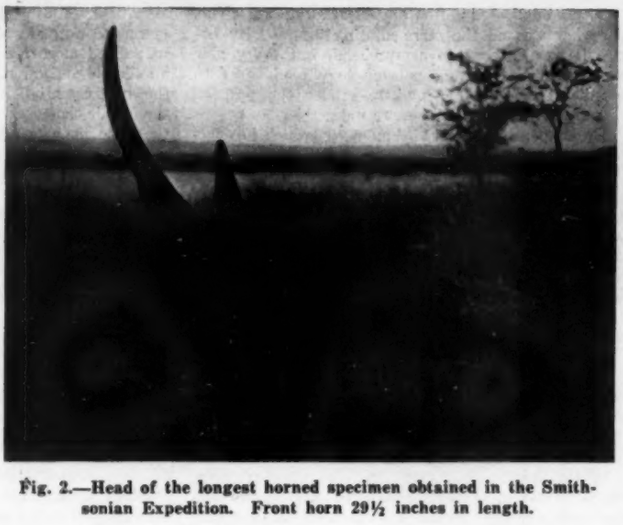


Fig. 2.—Head of the longest horned specimen obtained in the Smithsonian Expedition. Front horn 29½ inches in length.

The White Rhinoceros

"White" Only by Comparison

THE first number of volume 61 of the Smithsonian *Miscellaneous Collections* is the account, by Edmund Heller, Naturalist to the Smithsonian African Expedition, of the data collected on the race of so-called white rhinoceros.

GENERAL DESCRIPTION.

Of the general appearance of this species a good idea may be gained from our accompanying illustrations. The square-mouthed or white rhinoceros is a long-headed, tall-bodied animal with a flattened or truncate nose and a wide, square mouth. The excessively long head distinguishes this species at once from all other living forms. The ears are much longer and the feet larger than in the black rhinoceros. One of the peculiarities of this species is the prominent, rounded, fleshy hump upon the nape of the neck just forward of the withers. This hump is purely a muscular structure, and receives no support from the dorsal processes of the cervical vertebræ. One of the most obvious external differences of this rhinoceros is the lack of heavy body folds in its skin. The only evident folds are: a transverse one over the elbow joint, which completely encircles the external surface of the limb, a short transverse one on the nape immediately behind the ears, and a longer but less well marked fold on the throat. The elbow fold is the most distinct fold of the three, and is well marked in any body position. It is as distinct a fold in calves as in adults. The neck folds depend somewhat on the position of the head, the nape fold disappearing almost completely when the head is lowered to the level of the feet. The throat fold is affected similarly when the head is raised to the level of the back. The sides of the body are smooth, being without the rib-like folds so characteristic of the black rhinoceros. A further dermal character concerns the front edge of the thigh which is greatly compressed and stands out along the body as a thin, flattened ridge of hide. This latter character and the three short body folds described, are found in all the living species of rhinoceroses. Compared to the enormous body folds of the Indian rhinoceros, however, the present species appears to be quite devoid of folds.

In size this species exceeds but slightly, if at all, the great Indian single-horned species, and but little the black African species. Measurements of the length and height of the Indian species given by Lydekker are scarcely inferior to authentic dimensions of the largest South African specimens. Measurements of mounted skeletons of both species show the Indian one to be but little smaller in size. The black rhinoceros of East Africa stands several inches lower and measures less in height of head and body. This inferiority in length, however, is due largely to the much shorter head. The superiority in size of the white rhinoceros over the other living species, however, is not at all well established. In size the sexes are very similar; the male exceeding the female but little.

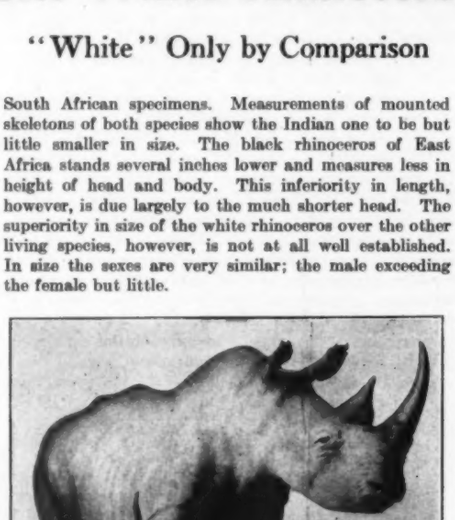


Fig. 3.—Mounted male Nile white rhinoceros in the United States National Museum, shot by Col. Theodore Roosevelt in the Lado Enclave.

The species are normally two-horned, the front horn greatly exceeding the rear one in size. The front horn is situated on a prominent bony boss at the tip of the nasal bones and is immediately followed by the rear horn, which is much compressed laterally and placed on the suture between the nasal and frontal bones. The front horn is squared in front where it partakes of the shape of the snout, and is normally curved backward as in the black rhinoceros. The usual length of this horn is 2 feet, although occasional specimens attain a length of 5 feet. The record horn for the South African race is 62½ inches. Such enlarged horns are attained only by the females in which they sometimes project forward in advance of the snout. The rear horn is usually low, sharply conical and considerably compressed. It seldom exceeds more than a few inches in height, and is occasionally wanting. The rear horn never approaches the front one in size as in the keitloa variety of the black rhinoceros, in which the two horns are quite equal. The rear horn is so small that it is obviously disappearing, the species showing a marked tendency to become single-horned, though actual single-horned specimens are rare.

COLORATION.

The skins of white rhinoceroses cannot under the most lenient consideration be classed as white. They are, however, distinctly lighter than those of the black species, and may on this account be allowed to retain their popular designation of white. The blackness of the mounted specimens in the British Museum is due to the black pigment put on by the taxidermists, and such specimens consequently do not represent the natural color of the animal. Their true color is smoke-gray of Ridgway,[1] a color conspicuously lighter than the dark clove-brown of their geographical ally, *Diceros bicornis*. The four adult skins in the collection show some variation, the color ranging from smoke-gray to broccoli-brown. The two male skins are lighter than the female skins, but the color differences are not consistent, the two female skins varying more in color from each other than they do from the male skins. Number 164,635, male, is light smoke-gray in color and is the lighter skin. It is quite similar in color to the colored figure of the white rhinoceros in Andrew Smith's "Illustrations of the Zoölogy of South Africa," 1849. The skin of the

[1] Ridgway, Robert T.: Color standards and color nomenclature Washington, 1913.

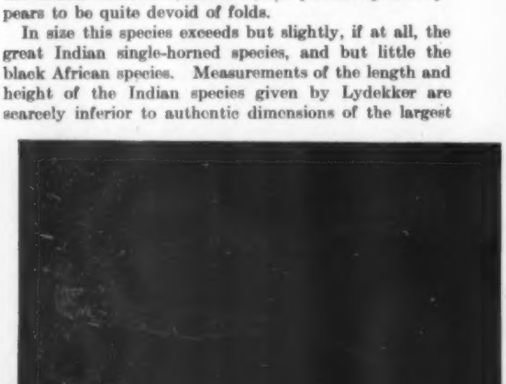


Fig. 4.—Lower jaw of Ceratotherium Simum Cottoni; female, aged.

Fig. 5.—Skull and upper jaw of Ceratotherium Simum Cottoni.

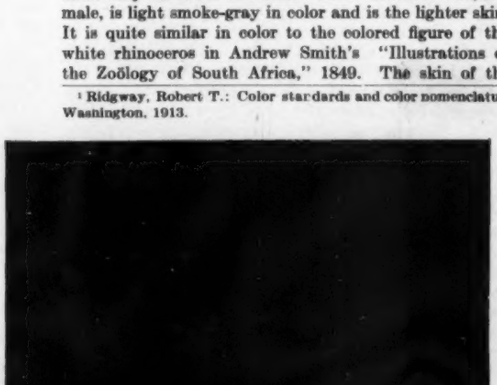


Fig. 6.—Side view of lower jaw of Ceratotherium Simum Cottoni; female, aged.

Fig. 7.—Ceratotherium Simum Cottoni; female, aged.

Fig. 8.—View from above of skull of Ceratotherium Simum Cottoni; female, aged.

other male, number 164,589, is also light smoke-gray of Ridgway. Number 164,592 is the darker female, the color being light broccoli-brown. Apparently the young soon attain the same shade of color as the adults, for the calf, number 164,588, has already attained adult coloration, and is actually somewhat darker than the lighter male.

The only parts of the body which show a growth of hair are the terminal margins of the ears and the apical one fourth of the tail. The hair of the ears is quite soft and is an inch or so in length. The hair covering of the tail is stiff and bristly, and confined to a streak along both edges of the flattened tip. In the two male skins the hair covering these parts is glossy black and quite profuse, but in the female skins the covering is much thinner and decidedly brownish in color. The young at birth are no more hairy than the adults, possessing only the ear and tail fringes of coarse hair.

MEASUREMENTS.

The flesh measurements of the specimens secured in the Lado by the Smithsonian African Expedition fall somewhat short in standing height and in length of head and body from those given by hunters of the white rhinoceros of the South. One of the commonest statements in the literature pertaining to the white rhinoceros is the comparison of its size as being greater than that of any other terrestrial mammal except the elephant. This is due to the exaggerated idea of its size given by sportsmen and is not based on the examination of specimens by such writers. The following table of measurements of skeletons shows conclusively how closely similar the Indian and the white rhinoceroses are in size. The flesh measurements of South African specimens given by Harris and by Coryndon greatly exceed the dimensions of any mounted specimens from that region. Harris gave the standing height attained by large bulls at the withers as from 6 feet 6 inches to 6 feet 8 inches. Coryndon records the heights of two bulls shot by him in Mashonaland as 6 feet 6 inches and 6 feet 9 inches, respectively. One of these bulls is now mounted in the British Museum and the other is in the Tring Museum. The British Museum specimen shows a height of 5 feet 10 inches, and the Tring specimen 6 feet 1½ inches. The great discrepancies between the flesh measurements and the specimens as mounted are no doubt due to errors made by the sportsmen in the field. Such exaggerations may be due to measuring over the curve of the shoulder or else forward to the top of the prominent hump on the neck At all events the mounted specimens should show at least as great height as the specimens in life, and the possibilities are that they actually exceed the flesh dimensions somewhat. The most reliable data in regard to exact size are to be obtained from mounted skeletons. The largest of the three skeletons measured shows a height of 5 feet and 9 inches, the other two are several inches lower. The tanned skins of the specimens secured in equatorial Africa, and now in the National Museum, show measurements slightly exceeding those taken in the flesh. It is very doubtful if the square-nosed rhinoceroses ever exceed a standing height at the withers of 6 feet. The flesh measurements of the Lado specimens agree fairly well with the dimensions of the known mounted specimens. This agreement is in accord with the relative size of the skulls from these respective northern and southern localities, which are practically equal. It is significant in this connection to find that the largest skull in the Lado series exceeds somewhat in bulk and zygomatic width any other known specimen, thus exceeding any known skull from South Africa. The longest skull measured, however, is a South African specimen preserved in the Museum of the Royal College of Surgeons at London.

GENERAL HISTORY.

In length of front horn, specimens of the white rhinoceros range from a few inches to 62 inches; seldom, however, exceeding 30 inches. At the extreme base in front the horn has a square or straight base which follows the outline of the snout, while in the black species this basal part of the horn is rounded. A further distinguishing peculiarity of the long horns of some females of the white species, is the straight or forward pitch, which is often carried to such an extreme that in feeding, the tip of the horn rests on the ground and is worn smooth on its outer face by contact with the soil.

Is Interstellar Space Empty?*

By Russell Sullivan

THE evidence for the existence of a resisting medium has been steadily accumulating, but of late a number of unrelated facts have greatly strengthened the probability that there is, scattered through space, a "something" which resists motion and absorbs the light of distant stars.

Turner has said that the light of faint and distant stars is red, and since it is improbable that the background of the visible universe is composed of red stars, the inference is that an absorbing medium has cut off the shorter wave-lengths and allowed the longer ones, such as the red, free passage through space. A red sunset illustrates the principle very well. In this case the increased thickness of the air near the horizon acts as a resisting medium absorbing the blue and violet, but permitting the yellow and red to strike the earth. Turner makes the resisting medium extinguish about half the light in 4,000 billion miles, while Kapteyn, allowing for contributory factors, only demands a density one tenth as great.

Since the eye is not sensitive to the colors of faint lights, these results have been obtained by photographing faint stars. As not enough stars impress themselves as we would be led to expect from visual considerations, it follows that the light from such stars is red, because it takes longer to photograph red light than the shorter wave-lengths. Thus we must infer the existence of an absorbing medium which eliminates the violets and blues, but allows the reds and yellows to make an unimpeded journey to distant parts of space.

While observing the minima of certain variable stars, Tikhoff and Nordmann announced independently a differential retardation of wave-length. The spectroscope showed that the "violet" minimum arrived several minutes later than the "blue" minimum. In fact, with shorter and shorter wave-lengths the minimum was correspondingly retarded. On the same scale of retardation, the violet waves from Neptune would be less than 1/100 of a second behindhand. Thus the violet and blue, on account of their shorter wave-lengths are more retarded by the resisting medium than the red.

Pickering, in a recent paper, has pointed out the curious fact that the majority of cometary aphelia lie in the region of the solar antapex. Either the sun is pursuing a curve, for which there is at present no evidence, or the cometary aphelia are swung back through space, so to speak, toward the antapex, by the pressure of a resisting medium. Such an effect would be inappreciable in the case of massive bodies like the planets; but comets, which are practically all volume and have no mass to speak of, might easily be disturbed by a resisting medium.

It has been known for some time that more than sixty per cent of the cometary perihelia lie within 45 degrees of longitude of the sun's way. Since the aphelia lie in the direction of the solar antapex, the perihelia would naturally cluster about the apex.

The ascending nodes of comets' orbits lie in longitude 80 degrees and 280 degrees, or, roughly speaking, such parallels of longitude pass within 10 degrees of the sun's way, i. e., near Lyra in the northern hemisphere and near a point half way between Sirius and Canopus in the southern hemisphere. It is evident that this tendency bears some relation to the sun's motion through space. Cometary orbits might be compared to the streaming flags of a swiftly moving boat.

While measuring the radial velocity of the spectroscopic binary β Scorpii, Slipher found that the calcium lines were faint and sharp and did not partake of the Doppler shift. It was inferred that they belonged to an invisible cloud of calcium some distance this side of the star. Similar lines have been noted in other stars of Scorpio; in fact, the occluded areas of Scorpio and Sagittarius bespeak the existance of a vast cosmic cloud in that part of the sky. Diametrically opposite, there is another nebulosity radiating from Orion, one of whose ramifications extends as far as the Pleiades. Calcium has again been noted in front of these stars. Thus the fabled antagonism of Orion and the Scorpion has its counterpart in the cosmic opposition of these nebulous clouds.

Slipher discovered recently that the nebula surrounding Merope in the Pleiades shines by the reflected light of the cluster. After carefully excluding the diffused light from Merope and the other bright stars, it was found that the spectrum of the nebula was the counterpart of the bright stars of the cluster. A nebula under these conditions could hardly be incandescent. The number of faint stars involved in the cluster is too small for an average region of the sky of that size. Therefore, it is probable that the haze through which the Pleiades shine absorbs the light of the faint stars beyond. The Pleiades are yellower than the average star of similar type of spectrum and this fact is additional evidence that they shine through an absorbing medium. Nova Persei illuminated a nebula which must have shone by reflected light, as its spectrum followed the vicissitudes of the Nova's after an interval of several months.

Bickerton says that many variable stars are nebulous at minimum—variability being caused by unequally brilliant hemispheres, which rotate and light up an invisible nebula when the brighter side is turned away from the earth.

W. W. Campbell suggests that a resisting medium may cause the variability of Cepheids. While receding from the earth a Cepheid variable is fainter than it is when traversing that part of its path which brings it toward us. As tidal friction has most likely caused both stars to turn the same hemisphere toward each other, one side would constantly be exposed to the resisting medium and thus be maintained at a higher temperature than the other.

Prof. See says that the whole sky is suffused with a background of faint nebulosity and Birkeland thinks that the amount of scattered material throughout space far exceeds in mass the quantity gathered together in suns and planets; such a nebulosity must be of excessive tenuity.

Comets' tails often show unmistakable signs of resistance. The distortion of the tail of Morehouse's comet (1908) gives evidence of some kind of pressure—the violence of the action seems to preclude the effect of the radiation pressure of sunlight. Prof. See postulates a "home of the comets" surrounding the solar system. From this reservoir of material stray wisps of nebulosity are drawn in from time to time and appear to men as comets. Such nebulosity might well be denser in some parts than others and thus absorb more light in certain spots than others. A similar cause could explain why certain variable stars exhibit retarded minima in the shorter wave-lengths, while others do not show this effect at all. The absorbing nebulosity could be placed at any distance in front of a star and still cause absorption of light and retardation of the shorter wave-lengths. There are evidently many "dark" nebulosities in the sky.

The corona and zodiacal light appear to be special cases of a universal phenomenon. The corona must be made of discrete particles since it shows curves similar to the lines of force in a magnet when the poles are sprinkled with iron filings. Excluding polar lights, Prof. Hale says that a faint aurora covers the night sky everywhere. It is conceivable that the faint luminosity above referred to might be due to the rapid collision of the earth's atmosphere with the small particles of the resisting medium. Some observers have noticed faint brown patches in the night sky. The various "dark days" of historical renown may have been caused by an encounter with a resisting medium which cut off the sun's light like a flock of migrating birds.

* Reproduced from *Popular Astronomy*.

The Human Worth of Rigorous Thinking*

Science a Creation of the Intellect in Its Quest for Harmony

By Prof. C. J. Keyser

But in the strong recess of Harmony,
Established firm abides the rounded Sphere.
—*Empedocles.*

AMONG the agencies that ameliorate life, what is the rôle of rigorous thinking? What is the rôle of the spirit that aspires always to logical righteousness, seeking "to frame a world according to a rule of divine perfection?"

Evidently that question is not one for adequate handling in an hour's address by an ordinary student of mathematics. Rather is it a subject for a long series of lectures by a learned professor of the history of civilization. Indeed, so vast is the subject that even an ordinary student of mathematics can detect some of the more obvious tasks such a philosophic historian would have to perform and a few of the difficulties he would doubtless encounter. It may be worth while to mention some of them.

Certainly one of the tasks, and probably one of the difficulties also, would be that of securing an audience—an audience, I mean, capable of understanding the lectures, for is not a genuine auditor a listener who understands? To understand the lectures it would seem to be necessary to know what that is which the lectures are about—that is, it would be necessary to know what is meant by rigorous thinking. To know this, however, one must either have consciously done some rigorous thinking or else, at the very least, have examined some specimens of it pretty carefully, just as, in order to know what good art is, it is, in general, essential either to have produced good art or to have attentively examined some specimens of it, or to have done both of these things. Here, then, at the outset our historian would meet a serious difficulty, unless his audience chanced to be one of mathematicians, which is (unfortunately) not likely, inasmuch as the great majority of mathematicians are so exclusively interested in mathematical study or teaching or research as to be but little concerned with the philosophical question of the human worth of their science. It is, therefore, easy to see how our lecturer would have to begin.

Ladies and gentlemen, we have met, he would say, to open a course of lectures dealing with the rôle of rigorous thinking in the history of civilization. In order that the course may be profitable to you, in order that it may be a course in ideas and not merely or mainly a verbal course, it is essential that you should know what rigorous thinking is and what it is not. Even I, your speaker, though a historian, might reasonably be held to the obligation of knowing that.

It is reasonable, ladies and gentlemen, it is reasonable to assume, he would say, that in the course of your education you neglected mathematics, and it is, therefore, probable or indeed quite certain that, notwithstanding your many accomplishments, you do not quite know, or rather, perhaps I should say, you are very far from knowing, what rigorous thinking is or what it is not. Of course, as you know, it is, generally speaking, much easier to tell what a thing is not than to tell what it is, and I might, he would say, I might proceed by way of a preliminary to indicate roughly what rigorous thinking is not. Thus I might explain that rigorous thinking, though much of it has been done in the world, and though it has produced a large literature, is nevertheless a relatively rare phenomenon. I might point out that a vast majority of mankind, a vast majority of educated men and women, have not been disciplined to think rigorously even those things that are most available for such thinking. I might point out that, on the other hand, most of the ideas with which men and women have constantly to deal are as yet too nebulous and vague, too little advanced in the course of their evolution, too little refined and defined, to be available for concatenative thinking and rigorous discourse. I should have to say, he would add, that, on these accounts, most of the thinking done in the world on a given day, whether done by men in the street or by farmers or factory-hands or merchants or administrators or physicians or lawyers or jurists or statesmen or philosophers or men of letters or students of natural science or even mathematicians (when not strictly employed in their own subject), comes far short of the demands and standards of rigorous thinking.

I might go on to caution you, our speaker would say, against the current fallacy, recently advanced by eloquent writers to the dignity of a philosophical tenet, of regarding what is called successful action as the touchstone of rigorous thinking. For you should know that much of what passes in the world for successful action proceeds from impulse or instinct and not from thinking of any kind; you should know that no action under the control of non-rigorous thinking can be strictly successful except by the favor of chance or through accidental compensation of errors; you should know that most of what passes for successful action, most of what the world applauds and even commemorates as successful action, so far from being really successful, varies from partial failure to failure that, if not total, would at all events be fatal in any universe that had the economic decency to forbid, under pain of death, the unlimited wasting of its resources. The dominant animal of such a universe would be in fact a superman. In our world the natural resources of life are superabundant, and man is poor in reason because he has been the prodigal son of a too opulent mother. But, ladies and gentlemen, ours speaker will conclude, you will know better what rigorous thinking is not when once you have learned what it is. This, however, cannot well be learned in a course of lectures in which that knowledge is presumed. I have, therefore, to adjourn this course until such time as you shall have gained that knowledge. It can not be gained by reading about it or hearing about it. The easiest way, for some persons the only way, to gain it is to examine with exceeding patience and care some specimens, at least one specimen, of the literature in which rigorous thinking is embodied. Such a specimen, he could say, is Dr. Thomas L. Heath's magnificent edition of Euclid where an excellent translation of the "Elements" from the definitive text of Heiberg is set in the composite light of critical commentary from Aristotle down to the keenest logical microscopists and histologists of our own day. If you think Euclid too ancient, and too stale even when seasoned with the wit of more than two thousand years of the acutest criticism, you may find a shorter and possibly a fresher way by examining minutely such a work as Veronese's "Grundzüge der Geometrie" or Hilbert's famous "Foundations of Geometry" or the late Pieri's "Della Geometria elementare come sistemi ipotetico-deduttivo." In works of this kind, of which the growing number is rather large, and not elsewhere, you will find, in its nakedness, purity and spirit, what you have neglected and what you need. You will note that in the beginning of such a work there is found a system of assumptions or postulates, discovered the Lord only and a few men of genius know where or how, selected perhaps with reference to simplicity and clearness, certainly selected with respect to their compatibility and independence, and, it may be, with respect also to categoricity. You will not fail to observe with the utmost minuteness, and from every possible angle, how it is that upon these postulates as a basis there is built up by a kind of divine masonry, little step by step, a stately structure of ideas, an imposing edifice of rigorous thought, a towering architecture of doctrine that is at once beautiful, austere, sublime and eternal. Ladies and gentlemen, our speaker will say, to accomplish that examination will require twelve months of pretty assiduous application. The next lecture of this course will be given one year from date.

On resuming the course what will our philosopher and historian proceed to say? He will begin to say what, if he says it concisely, will make up a very large volume. Room is lacking here, even if competence were not, for so much as an adequate outline of the matter. It is possible, however, to draw with confidence a few of the larger lines that would have to enter such a sketch.

What is it that our speaker will be obliged to deal with first? I do not mean obliged logically or obliged by an orderly development of his subject. I mean obliged by the expectation of his hearers. Every one can answer that question. For presumably the audience represents the spirit of the times, and this age is, at least to a superficial observer, an age of engineering. Now, what is engineering? Well, the charter of the Institution of Civil Engineers tells us that engineering is the "art of directing the great sources of power in Nature for the use and convenience of man." By Nature here must be meant external or physical nature, for, if internal nature were also meant, *every* good form of activity would be a species of engineering, and may be it is such, but that is a claim which even engineers would hardly make and poets would certainly deny. Use and convenience—these are the key-bearing words. It is perfectly evident that our lecturer will have to deal first of all with what the world would call the "utility" of rigorous thinking, that is to say, with the applications of mathematics and especially with its applications to problems of engineering. If he really knows profoundly what mathematics is, he will not wish to begin with applications or even to make applications a major theme of his discourse, but he must, and he will do so uncomplainingly as a concession to the external-mindedness of his time and his audience. He will not only desire to show his audience applications of mathematics to engineering, but, being a historian of civilization, he will especially desire to show them the development of such applications from the earliest times, from the building of pyramids and the mensuration of land in ancient Egypt down to such splendid modern achievements as the designing and construction of an Eads bridge, an ocean "Imperator" or a Panama canal. The story will be long and difficult, but it will edify. The audience will be amazed at the truth if they understand. If they do not understand the truth fully, our speaker must at all events contrive that they shall see it in glimmers and gleams and, above all, that they shall acquire a feeling for it. They must be led to some acquaintance with the great engineering works of the world, past and present; they must be given an intelligent conception of the immeasurable contribution such works have made to the comfort, convenience and power of man; and especially must they be convinced of the fact that not only would the greatest of such achievements have been, except for mathematics, utterly impossible, but that such of the lesser ones as could have been wrought without mathematical help could not have been thus accomplished without wicked and pathetic waste both of material resources and of human toil. In respect to this latter point, the relation of mathematics to practical economy in large affairs, our speaker will no doubt invite his hearers to read and reflect upon the ancient work of Frontinus on the "Water Supply of the City of Rome" in order that thus they may gain a vivid idea of the fact that the most *practical* people of history, despising mathematics and the finer intellectualizations of the Greeks, were unable to accomplish their own great engineering feats except through appalling waste of materials and men. Our lecturer will not be content, however, with showing the service of mathematics in the prevention of waste; he will show that it is indispensable to the productivity and trade of the modern world. Before quitting this division of his subject he will have demonstrated that, if all the contributions which mathematics has made, and which nothing else could make, to navigation, to the building of railways, to the construction of ships, to the subjugation of wind and wave, electricity and heat, and many other forms and manifestations of energy, he will have demonstrated, I say, and the audience will finally understand, that, if all these contributions were suddenly withdrawn, the life and body of industry and commerce would suddenly collapse as by a paralytic stroke, the now splendid outer tokens of material civilization would perish, and the face of our planet would quickly assume the aspect of a ruined and bankrupt world.

As our lecturer has been constrained by circumstances to back into his subject, as he has, that is, been compelled to treat first of the service that mathematics has rendered engineering, he will probably next speak of the applications of mathematics to the so-called natural sciences—the more properly called experimental sciences—of physics, chemistry, biology, economics, psychology, and the like. Here his task, if it is to be, as it ought to be, expository as well as narrative, will be exceedingly hard. For how can he weave into his narrative an intelligible exposition of Newton's "Principia," Laplace's "Mécanique Céleste," Lagrange's "Mécanique Analytique," Gauss's "Théoria Motus Corporum Cœlestium," Fourier's "Theorie de la Chaleur," Max-

*An address delivered before the Mathematical Colloquium of Columbia University, and published in *Science*.

well's "Electricity and Magnetism," not to mention scores of other equally difficult and hardly less important works of a mathematical-physical character? Even if our speaker knew it all, which no man can, he could not tell it all intelligibly to his hearers. These will have to be content with a rather general and superficial view, with a somewhat vague intuition of the truth, with fragmentary and analogical insights gained through settings-forth of great things by small; and they will have to help themselves and their speaker, too, by much pertinent reading. No doubt the speaker will require his hearers, in order that they may thus gain a tolerable perspective, to read well not only the two volumes of the magnificent work of John Theodore Merz dealing with the history of European thought in the nineteenth century, but also many selected portions of the kindred literature there cited in richest profusion. The work treats mainly of natural science, but it deals with it philosophically, under the larger aspect, that is, of science regarded as thought. By the help of such literature in the hands of his hearers, our lecturer will be able to give them a pretty vivid sense of the great and increasing rôle of mathematics in suggesting, formulating and solving problems in all branches of natural science. Whether it be with "the astronomical view of nature" that he is dealing, or "the atomic view" or "the mechanical view" or "the physical view" or "the morphological view" or "the genetic view" or "the vitalistic view" or "the psychophysical view" or "the statistical view," in every case, in all these great attempts of reason to create or to find a cosmos amid the chaos of the external world, the presence of mathematics and its manifold service, both as instrument and as norm, illustrate and confirm the Kantian and Riemannian conception of natural science as "the attempt to understand nature by means of exact concepts."

In connection with this division of his subject, our speaker will find it easy to enter more deeply into the spirit and marrow of it. He will be able to make it clear that there is a sense, a just and important sense, in which all thinkers and especially students of natural science, though their thinking is for the most part not rigorous, are yet themselves contributors to mathematics. I do not refer to the powerful stimulation of mathematics by natural science in furnishing it with many of its problems and in constantly seeking its aid. What I mean is that all thinkers and especially students of natural science are engaged, both consciously and unconsciously, both intentionally and unintentionally, in the mathematicization of concepts, that is to say, in so transforming and refining concepts as to fit them finally for the amenities of logic and the austerities of rigorous thinking. We are dealing here, our speaker will say, with a process transcending conscious design. We are dealing with a process deep in the nature and being of the psychic world. Like a child, an idea, once it is born, once it has come into the realm of spiritual light, possibly long before such birth, enters upon a career, a career, however, that, unlike the child's, seems to be immortal. In most cases and probably in all, an idea, on entering the world of consciousness, is vague, nebulous, formless, not at once betraying either what it is or what it is destined to become. Ideas, however, are under an impulse and law of amelioration. The path of their upward striving and evolution, often a long and winding way, leads toward precision and perfection of form. The goal is mathematics. Witness, for example, our lecturer will say, the age-long travail and aspiration of the great concept now known as mathematical continuity, a concept whose inner structure is even now known and understood only of mathematicians, though the ancient Greeks helped in molding its form and though it has long been, if somewhat blindly, yet constantly employed in natural science as when a physicist, for example, or an astronomer uses such numbers as e and π in computation. Witness, again, how that supreme concept of mathematics, the concept of function, has struggled through thousands of years to win at length its present precision of form out of the nebulous sense, which all minds have, of the mere dependence of things on other things. Witness, too, he will say, the mathematical concept of infinity, which prior to a half-century ago was still too vague for logical discourse, though from remotest antiquity the great idea has played a conspicuous rôle, mainly emotional, in theology, philosophy and science. Like examples abound, showing that one of the most impressive and significant phenomena in the life of the psychic world, if we will but discern and contemplate it, is the process by which ideas advance, often slowly indeed but surely, from their initial condition of formlessness and indetermination to the mathematical estate. The chemicization of biology, the physicization of chemistry, the mechanicization of physics, the mathematicization of mechanics, these well-known tendencies and drifts in science do but illustrate on a large scale the ubiquitous process in question.

At length, ladies and gentlemen, our speaker will say, in the light of the last consideration, the deeper and larger aspects of our subject are beginning to show themselves, and there is dawning upon us a wonderful vision. The nature, function and life of the entire conceptual world seem to come within the circle and scope of our present enterprise. We are beginning to see that to challenge the human worth of mathematics, to challenge the worth of rigorous thinking, is to challenge the worth of all thinking, for now we see that mathematics is but the ideal to which all thinking, by an inevitable process and law of the human spirit, constantly aspires. We see that to challenge the worth of that ideal is to arraign before the bar of values what seems the deepest process and inmost law of the universe of thought. Indeed we see that in defending mathematics we are really defending a cause yet more momentous, the whole cause, namely, of the conceptual procedure of science and the conceptual activity of the human mind, for mathematics is nothing but such conceptual procedure and activity come to its maturity, purity and perfection.

Now, ladies and gentlemen, our lecturer will say, I cannot in this course deal explicitly and fully with this larger issue. But, he will say, we are living in a day when that issue has been raised; we happen to be living in a time when, under the brilliant and effective leadership of such thinkers as Prof. Bergson and the late Prof. James, the method of concepts, the method of intellect, the method of science, is being powerfully assailed; and, while I heartily welcome this attack of criticism as causing scientific men to reflect more deeply on the method of science, as exhibiting more clearly the inherent limitations of the method, and as showing that life is so rich as to have many precious interests and the world much truth beyond the reach of that method, yet I cannot refrain, he will say, from attempting to point out rather carefully what seems to me a radical error of the critics, a fundamental error of theirs, in respect to what is the highest function of conception and in respect to what is the real aim and ideal of the life of intellect. For we shall thus be led to a deeper view of our subject proper.

These critics find, as all of us find, that what we call mind, or our minds are, in some mysterious way, functionally connected with certain living organisms known as human bodies, they find that these living bodies are constantly immersed in a universe of matter and motion in which they are continually pushed and pulled, heated and cooled, buffeted and jostled about—a universe that, according to James, would, in the absence of concepts, reveal itself as "a big, blooming, buzzing confusion,"—though it is hard to see how such a revelation could happen to anyone devoid of the concept "confusion," but let that pass; they find that our minds get into some initial sort of knowing connection with that external blooming confusion through what they call the sensibility of our bodies, yielding all manner of sensations as of weights, pressures, pushes and pulls, of intensities and extensities of brightness, sound, time, colors, space, odors, tastes, and so on; they find that we must, on pain of organic extinction, take some account of these elements of the material world; they find that, as a fact, we human beings constantly deal with these elements through the instrumentality of concepts; they find that the effectiveness of our dealing with the material world is precisely due to our dealing with it conceptually: they infer that, therefore, dealing with matter is exactly what concepts are for, saying with Ostwald, for example, that the goal of natural science, the goal of the conceptual method of mind, "is the domination of nature by man;" not only, our speaker will say, do our critics find that we deal with the material world conceptually, and effectively because conceptually, but they find also that life has interests and the world values not accessible to the conceptual method, and as this method is the method of the intellect, they conclude, not only that the intellect cannot grasp life, but that the aim and ideal of intellect is the understanding and subjugation of matter, saying with Prof. Bergson "that our intellect is intended to think matter," "that our concepts have been formed on the model of solids," "that the essential function of our intellect . . . is to be a light for our conduct, to make ready for our action on things," that "the intellect is characterized by a natural inability to understand life," that "intellect always behaves as if it were fascinated by the contemplation of inert matter," that "intelligence . . . aims at a practically useful end," that "the intellect is never quite at its ease, . . . except when it is working upon inert matter, more particularly upon solids," and much more to the same effect.

Now, ladies and gentlemen, our speaker will ask, what are we to think of this? What are we to think of this valuation of the science-making method of concepts? What are we to think of the aim and ideal here ascribed to the intellect and of the station assigned it among the faculties of the human mind? In the first place, he will say, it ought to be evident to the critics themselves, and evident to them even in what they esteem the poor light of intellect, that the above-sketched movement of their minds is a logically unsound movement. They do not indeed contend that, because a living being in order to live must deal with the material world, it must, therefore, do so by means of concepts. The lower animals have taught them better. But neither does it follow that, because certain bipeds in dealing with the material world deal with it conceptually, the essential function of concepts is just to deal with matter. Nor does such an inference respecting the essential function of concepts follow from the fact that the superior effectiveness of man's dealing with the physical world is due to his dealing with it conceptually. For it is obviously conceivable and supposable that such conceptual dealing with matter is only an incident or byplay or subordinate interest in the career of concepts. It is conceivably possible that such employment is only an avocation, more or less serious indeed and more or less advantageous, yet an avocation, and not the vocation, of intellect. Is it not evidently possible to go even further? Is it not logically possible to admit or to contend that, inasmuch as the human intellect is functionally attached to a living body which is itself plunged in a physical universe, it is absolutely necessary for the intellect to concern itself with matter in order to preserve, not indeed the animal life of man, but his intellectual life—is it not allowable, he will say, to admit or to maintain *that* and at the same time to deny that such concernment with matter is the intellect's chief or essential function and that the subjugation of matter is its ideal and aim?

Of course, our lecturer will say, our critics might be wrong in their logic and right in their opinion, just as they might be wrong in their opinion and right in their logic, for opinion is often a matter, not of logic or proof, but of temperament, taste and insight. But, he will say, if the issue as to the chief function of concepts and the ideal of the intellect is to be decided in accordance with temperament, taste and insight, then there is room for exercise of the preferential faculty, and alternatives far superior to the choice of our critics are easy enough to find. It may accord better with our insight and taste to agree with Aristotle that "It is owing," not to the necessity of maintaining animal life or the desire of subjugating matter, but "it is owing to their *wonder* that men both now begin and at first began to philosophize; they *wondered* originally at the obvious difficulties, then advanced little by little and stated the difficulties about the greater matters." The striking contrast of this with the deliverances of Bergson is not surprising, for Aristotle was a pupil of Plato and the doctrine of Bergson is that of Plato completely inverted. It may accord better with our insight and taste to agree with the great C. G. I. Jacobi, who, when he had been reproached by Fourier for not devoting his splendid genius to physical investigations, replied that a philosopher like his critic "ought to know that the unique end of science is," not public utility and applications to natural phenomena, but "is the honor of the human spirit." It may accord better with our temperament and insight to agree with the sentiment of Diotima: "I am persuaded that all men do all things, and the better they are the better they do them, in the hope," not of subjugating matter, but "in the hope of the glorious fame of immortal virtue."

But it is unnecessary, ladies and gentlemen, it is unnecessary, our speaker will say, to bring the issue to final trial in the court of temperaments and tastes. We should have there a too easy victory. The critics are psychologists, some of them eminent psychologists. Let the issue be tried in the court of psychology, for it is there that of right it belongs. They know the fundamental and relevant facts. What is the verdict according to these? The critics know the experiments that have led to and confirmed the psychological law of Weber and Fechner and the doctrine of thresholds; they know that,

in accordance with that doctrine and that law, an appropriate stimulus, no matter what the department of sense, may be finite in amount and yet too small, or finite and yet too large, to yield a sensation; they know that the difference between two stimuli appropriate to a given sense department, no matter what department, may be a finite difference and yet too small for sensibility to detect, or to work a change of sensation; they ought to know, though they seem not to have recognized, much less to have weighed, the fact that, owing to the presence of thresholds, the greatest number of distinct sensations possible in any department of sense is a *finite* number; they ought to know that the number of different departments of sense is also a *finite* number; they ought to know that, therefore, the total number of distinct or different *sensations* of which a human being is capable is a *finite* number; they ought to know, though they seem not to have recognized the fact, that, on the other hand, the world of *concepts* is of *infinite* multiplicity, that concepts, the fruit of intellect, as distinguished from sensations, the fruit of sensibility, are *infinite* in number; they ought, therefore, to see, our speaker will say, though none of them has seen, that in attempting to derive intellect out of sensibility, in attempting to show that (as James says) "concepts flow out of percepts," they are confronted with the problem of bridging the immeasurable gulf between the finite and the infinite, of showing, that is, how an infinite multiplicity can arise from one that is finite. But even if they solved that apparently insoluble problem, they would not yet be in position to affirm that the function of intellect and its concepts is, like that of sensibility, just the function of dealing with matter, as the function of teeth is biting and chewing. Far from it.

Let us have another look, the lecturer will say, at the psychological facts of the case. Owing to the presence of thresholds in every department of sense it may happen and indeed it does happen constantly, in every department, that three different amounts of stimulus of a same kind give *three sensations such that two of them are each indistinguishable from the third and yet are distinguishable from one another.* Now, for sensibility in any department of sense, two magnitudes of stimulus are unequal or are equal according as the sensations given by them are or are not distinguishable. Accordingly in the world of sensible magnitudes, in the sensible universe, in the world, that is, of *felt* weights and thrusts and pulls and pressures, of *felt* brightnesses and warmths and lengths and breadths and thicknesses and so on, in this world, which is the world of matter, *magnitudes are such that two of them may each be equal to a third without being equal to one another.* That, our speaker will say, is a most significant fact and it means that the sensible world, the world of matter, is irrational, infected with contradiction, contravening the essential laws of thought. No wonder, he will say, that old Heraclitus declared the unaided senses "give a fraud and a lie."

Now, our speaker will ask, what has been and is the behavior of intellect in the presence of such contradiction? Observe, he will say, that it is intellect, and not sensibility, that detects the contradiction. Of the irrationality in question sensibility remains insensible. The data among which the contradiction subsists are indeed rooted in the sensible world, they inhere in the world of matter, but the contradiction itself is known only to the logical faculty called intellect. Observe also, he will say, and the observation is important, that such contradictions do not compel the intellect to any activity whatever intended to preserve the life of the living organism to which the intellect is functionally attached. That is a lesson we have from our physical kin, the beasts. What, then, *has* the intellect done because of or about the contradiction? Has it gone on all these centuries, as our critics would have us believe, trying to "think matter," as if it did not know that matter, being irrational, is not thinkable? Far from it, he will say, the intellect is no such ass.

What it has done, instead of endlessly and stupidly besieging the illogical world of sensible magnitudes with the machinery of logic, what it has done, our lecturer will say, is this: It has created for itself another world. It has not rationalized the world of sensible magnitudes. That, it knows, cannot be done. It has discerned the ineradicable contradictions inherent in them, and by means of its creative power of conception it has made a new world, a world of conceptual magnitudes that, like the continua of mathematics, are so constructed by the spiritual architect and so endowed by it as to be free alike from the contradictions of the sensible world and from all thresholds that could give them birth. Indeed conception, to speak metaphorically in terms borrowed from the realm of sense, is a kind of infinite sensibility, transcending any finite distinction, difference or threshold, however minute or fine. And, now, our speaker will say, it is such magnitudes, magnitudes created by intellect and not those discovered by sense, though the two varieties are frequently not discriminated by their names, it is such conceptual magnitudes that constitute the subject-matter of science. If the magnitudes of science, apart from their rationality, often bear in conformation a kind of close resemblance to the magnitudes of sense, what is the meaning of the fact? It means, contrary to the view of Bergson but in accord with that of Poincaré, that the free creative artist, intellect, though it is not constrained, yet has chosen to be guided, in so far as its task allows, by facts of sense. Thus we have, for one example among many, conceptual space and sensible space so much alike in conformation that, though one of them is rational and the other is not, the undiscriminating hold them as the same.

And now, our lecturer will ask, for we are nearing the goal, what then *is* the motive and aim of this creative activity of the intellect? Evidently it is not to preserve and promote the life of the human body, for animals flourish without the aid of concepts and despite the contradictions in the world of sense. The aim is, he will say, to preserve and to promote the life of the intellect itself. In a realm infected with irrationality, with omnipresent contradictions of the laws of thought, intellect cannot live, much less flourish; in the world of sense, it has no proper subject-matter, no home, no life. To live, to flourish, it must be able to think, to think in accordance with the laws of its being. It is stimulated and its activity sustained by two opposite forces—discord and concord. By the one it is driven; by the other, drawn. Intellect is a perpetual suitor. The object of the suit is not the conquest of matter, it is a thing of mind, it is the music of the spirit, it is Harmonia, the beautiful daughter of the muses. The aim, the ideal, the beatitude of intellect is harmony. That is the meaning of its endless talk about compatibilities, consistencies and concords, and that is the meaning of its endless battling and circumvention and transcendence of contradiction. But what of the applications of science and public service? These are by-products of the intellect's aim and of the pursuit of its ideal. Many things it regards as worthy, high and holy, applications of science, public service, the "wonder" of Aristotle, Jacobi's "honor of the human spirit," Diotima's "glorious fame of immortal virtue," but that which, by the law of its being, intellect seeks above all and perpetually pursues and loves, is harmony. It is for a home and a dwelling with her that intellect creates a world; and its admonition is: Seek ye first the Kingdom of Harmony, and all these things shall be added unto you.

And the ideal and admonition, thus revealed in the light of analysis, are justified of history. Inverting the order of time, we have only to contemplate the great periods in the intellectual life of Paris, Florence and Athens. If, among these mightiest contributors to the spiritual wealth of man, Athens is supreme, she is also supreme in her devotion to the intellect's ideal. It is of Athens that Euripides sings:

> The sons of Erectheus, the olden,
> Whom high gods planted of yore
> In an old land of heaven upholden,
> A proud land untrodden of war;
> They are hungered, and lo, their desire
> With wisdom is fed as with meat;
> In their skies is a shining of fire,
> A joy in the fall of their feet;
> And thither with manifold dowers,
> From the north, from the hills, from the morn,
> The Muses did gather their powers,
> That a child of the Nine should be born,
> And Harmony, sown as the flowers,
> Grew gold in the acres of corn.[1]

And thus, ladies and gentlemen, our lecturer will say, what I wish you to see here is, that Science, and especially Mathematics, the ideal form of science, are creations of Intellect in its quest for Harmony. It is as such creations that they are to be judged and their human worth appraised. Of the applications of mathematics to engineering and of its service in natural science, I have spoken at length, he will say, in the course of previous lectures. Other great themes of our subject remain for consideration. To appraise the worth of mathematics as a discipline in the art of rigorous thinking and as a means of giving wing to the subtler imagination; to estimate and explain its value as a norm for criticism and for guidance of speculation and pioneering in fields not yet brought under the dominion of logic; to estimate its esthetic worth as showing forth in psychic light the law and order of the psychic world; to evaluate its ethical significance in rebuking by its certitude and eternality the facile skepticism that doubts all knowledge, and especially in serving as a retreat for the spirit when as at times the world of sense seems madly bent on heaping strange misfortunes up and "to and fro the chances of the years dance like an idiot in the wind;" to give a sense of its religious value in "the contemplation of ideas under the form of eternity," in disclosing a cosmos of perfect beauty and everlasting order and in presenting there, for meditation, endless consequences traversing the rational world and seeming to point to a mystical region above and beyond: these and similar themes, our speaker will say, remain to be dealt with in subsequent lectures of the course.

[1] Translation by Prof. Gilbert Murray.

EXPERIMENTS with various chemical extinguishers for fighting national forest fires have not been very successful. The unlimited supply of oxygen in the open, forest officers say, tends to neutralize the effect of the chemicals.

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